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Bearing Zone Cracking of Precast Prestressed Concrete Bridge Girders

Final Report

Prepared for

Office of Materials and Research
Georgia Department of Transportation

GDOT Research Project No. 05-14

by

Patrick J. Kelly and Lawrence F. Kahn

February 2007

Contract Research
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Executive Summary

This report presents the results of a research project that tested five friction reducing techniques on the bearing ends of precast prestressed concrete bridge girders. The five techniques were the following: an oil coated surface, embedded steel plate with an oil coated surface, embedded steel angle with an oil coated surface, teflon pad, and a wax lubricant. The different techniques were used to reduce the friction tensile cracks that are induced at the precast plant when the ends of the girders slide along the steel casting bed after the prestressing strands are cut. To find the most effective friction reducing technique, laboratory friction tests were conducted to see which technique required the least horizontal force to initiate motion in 600 pound concrete blocks. Field tests were conducted at Standard Concrete Products plant by measuring strain, camber, and girder slide when the girders were on the casting bed before and after the prestressing strands were cut, and after the girders were moved off the casting bed. A qualitative analysis was conducted by observing which technique prevented tensile cracks from developing at the bearing ends and which did not. Results indicated the following: the embedded steel plate with an oil coated surface reduced friction the greatest between the concrete block and the steel surface in the laboratory tests; the embedded steel plate and angle provided the least frictional restraint between the ends of the girder and the steel casting bed in the field tests; the teflon pad and wax lubricants provided significantly reduced friction compared to the standard oil-coated steel surface; and girders with the embedded steel plate exhibited no tensile cracking at the ends of the girder in the bearing zone.

Acknowledgments

The research presented in this paper was sponsored by the Georgia Department of Transportation under Georgia DOT Task Order No. 02-20, Research Project No. 05-14. During the course of this research project, the research team at Georgia Tech received valuable support and guidance from Georgia DOT professionals including Mr. Paul Liles, Mr. Myron Banks, Mr. Rick Deaver, Ms. Supriya Kamatkar, and Ms. Lyn Clements. Their support and guidance are greatly acknowledged.

The opinions and conclusions expressed herein are those of the authors and do not represent the opinions, conclusions, policies, standards or specifications of the Georgia Department of Transportation or of the other sponsoring and cooperating organizations.

The following students aided in the laboratory and field studies: John Bunyasaranand, Jon Hurff, Felix Kim, Ben Allread, and Andreas Willecke. All of the personnel at Standard Concrete Products were extremely helpful in conducting the field studies; plant manager Craig Thompson and production manager David Hennessey were particularly helpful along with Mr. Richard Potts who provided many valuable suggestions. Their efforts are gratefully acknowledged.

Dr. Russell Gentry and Dr. Kimberly Kurtis assisted with the experimental studies.

The wax materials were donated by Mr. Allan Short, Cellulose Solutions, Daphne, Alabama.

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CHAPTER I

INTRODUCTION

Many highway bridges are designed and constructed using precast prestressed concrete bridge girders with span lengths ranging from 100 feet to 180 feet in length. Problems occur with the construction of these heavy girders with bearing zone cracks developing at the precast plant. These cracks develop from the frictional restraint as the ends of the girder slide along the casting bed just after the prestressing strands are cut. This friction force results in a tensile stress at the ends which causes cracks to develop and the bottom corners to spall off.

The Georgia Department of Transportation currently does not specify any specific method to reduce the friction between the ends of the girders and the casting bed. This research was designed to investigate friction reducing techniques to eliminate bearing zone cracking of prestressed concrete girders.

The South Carolina Department of Transportation has specified the use of a steel plate to be embedded into the ends of the girder at the time of construction at the precast plant. This solution has been observed to be effective in eliminating the bearing zone cracks from developing.

This research shows which methods effectively reduce tensile stresses at the ends of the girders and eliminate bearing zone cracks from developing during construction at the precast plant.

1.1 Research Objectives

The purpose of this research was to determine experimentally which of the five friction reducing techniques results in the least frictional sliding resistance between concrete and a steel casting bed. The five techniques studied were: use the current method of oil on the steel bed, a teflon pad which has been used on some projects, wax lubricant suggested by Mr. Richard Potts of Standard Concrete, an embedded steel plate like that specified by the South Carolina DOT, and an embedded steel angle like the ones used at corners of reinforced concrete corbels. No friction reducing technique was also studied as a reference. The smallest coefficient of friction between a concrete block and a steel beam was measured and field tests were conducted to determine which technique prevented bearing zone cracks from developing.

1.2 Need for Research

This research was necessary because cracks in the bearing zone region of precast prestressed concrete bridge girders require repairs. These cracks allow water to easily reach the steel reinforcement and accelerate corrosion of the steel. The corrosion causes further cracking at the ends of the girder and reduces the service life. Cracking in the bearing region reduces the effective bearing area of the girder. Reducing the bearing area increases the bearing stresses and could cause bearing failure in the concrete. Eliminating such cracking would reduce repair costs and improve the economics of precast prestressed bridge girders.

1.3 Experimental and Qualitative Program

The experimental and qualitative program involved the following phases:

1. Experimentally measure which technique produces the least coefficient of friction between a concrete block and a steel surface.

2. Conduct field tests to qualitatively determine which end condition provides the least frictional restraint between the ends of the girder and the casting bed.
3. Conduct field tests to observe which end condition prevents bearing zone cracks from developing.

1.4 Organization of Report

This report begins with a background review in Chapter II that covers the definition of friction and how to calculate the coefficient of friction between two surfaces, the definition of strain and how to calculate the strain between two points, the definition of camber, and the definition and characteristics of transfer length in prestressed concrete.

Chapters III and IV focus on the laboratory experiment. Chapter III states the purpose of the laboratory experiment and explains the reason for conducting the tests. Chapter IV discusses the results and conclusions found from the data collected during the experiment.

Chapters V and VI focus on the field test experiments. Chapter V states the procedure and tests performed in the field. Chapter VI discusses the qualitative results and conclusions found from the field test research.

Chapter VII provides conclusions and recommendations based upon this research project.

CHAPTER II

BACKGROUND REVIEW

2.1 Introduction

This review provides information on the factors that the different techniques affect. Each end condition has a coefficient of friction that was measured in the laboratory experiment of this project. Strain and camber were calculated from the field tests and were qualitatively analyzed to determine which technique reduced friction the greatest. In the case of prestressed concrete girders, the transfer length of the prestressing strands is affected by the sliding friction force at the ends of the girder; the transfer length is extended as the friction is increased.

2.2 Friction

Friction is the resistance to motion that exists when any two surfaces slide against one another. Friction will vary depending on the type of surfaces that are in contact. The magnitude of the surface area of the two surfaces in contact does not affect the frictional force[1]. The frictional force is proportional to the normal force with the surface it is sliding against. When two surfaces are in contact with each other for a long period of time, friction increases. With metal on metal, the increase is virtually instant. However, the addition of a lubricant may nullify this effect[1]. Static friction requires the greatest force to initiate motion. Once in motion, that same object requires a lesser force to continue its motion. The coefficient of static friction is represented by Equation (1)[1]:

$$\mu_s = f_s/N \qquad \text{Equation (1)}$$

Where: μ_s = the coefficient of static friction

f_s = the force of friction

N = the normal force in contact with the sliding surface

2.3 Strain

When a structure is subjected to an applied load, the length of that structure changes. For an axially loaded structure, the normal strain is represented by Equation (2)[4]:

$$\varepsilon = \delta/L \qquad \text{Equation (2)}$$

Where: ε = the axial strain in the cross section

δ = the change in length represented by $L_1 - L$

L_1 = the new length after the load was applied

L = the length before the load was applied

For this project the strain is being measured in a 10 in. length at the ends of the girder at x inches above the bottom of the girder. While the strain varies along this 10 in. length, the average strain in one girder may be compared to the average strain in another.

2.4 Camber

Camber is an upward deflection typically seen in all precast prestressed concrete flexural members. This camber is generated by the eccentricity of prestressing force with respect to the cross section of the concrete section[7]. Camber is beneficial for serviceability of deflections. Camber also places the concrete section below the neutral axis in a pre-compressive state so the girder's tensile stress capacity is increased. Camber can be computed by methods outlined in PCI Bridge Design Handbook[7].

2.5 Transfer Length

Transfer length is the length that is required to transfer the prestressing force present in the prestressing strand to the concrete cast around it. When the prestressing strands are cut by torch or other method from its anchorage, the transfer length is developed. A sufficient bond between the prestressing strands and the concrete must be present for the force from the strands to fully transfer to the concrete[3].

A sufficient amount of transverse steel must be present in the transfer region of the girder to provide confinement for the prestressing strands. Without enough reinforcement, cracking of the concrete will develop, increasing the transfer length. A relationship of stress in the prestressing strand to bond length is shown in Figure 2.1[3].

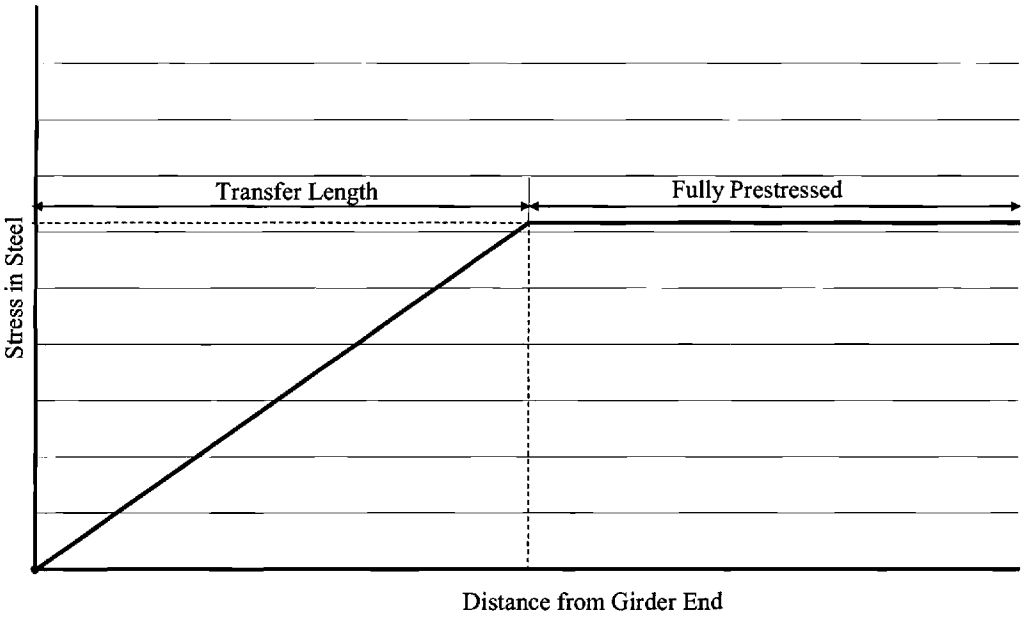


Figure 2.1 Steel stress vs. distance from end of girder

At the end of the girder, stress in the concrete is zero where the bond with the strand and concrete starts and is assumed to increase at a linear rate to a distance that is equivalent to the transfer length of the strand. After the transfer length has been reached, the strand is believed to have fully transferred the prestress force to the concrete and the precompressive stress is assumed to be constant beyond that distance[2].

AASHTO states that the transfer length of a prestressed strand, given in Equation (3) shall be taken as[3]:

$$l_t = \frac{f_{se} d_b}{3} \qquad \text{Equation (3)}$$

Where: f_{sc} = the effective stress in the strands after losses (ksi)

d_b = strand diameter (in)

CHAPTER III

LABORATORY EXPERIMENT SET-UP AND PROCEDURE

3.1 Introduction

In order to determine the most effective friction reducing technique of prestressed concrete bridge girders, a laboratory experiment was set up to measure the coefficient of friction between a concrete block with various friction reducing techniques sliding along the top surface of a steel beam. The steel beam represented the bottom steel bed form at the precast concrete plant.

3.2 Test Set-up

Figure 3.1 shows the laboratory experiment set-up that was used to test the friction reducing techniques.

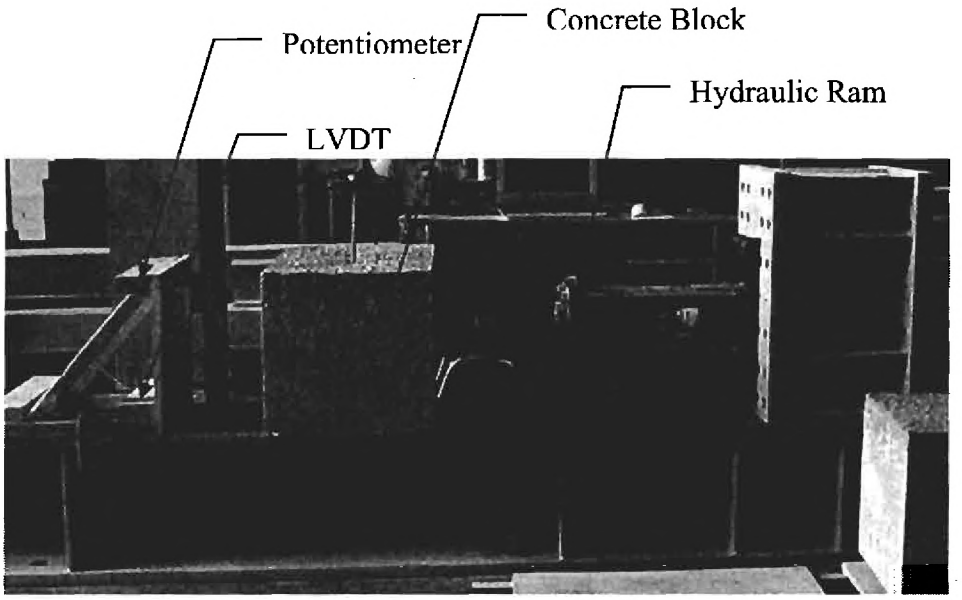


Figure 3.1 Laboratory experiment set-up

As shown in Figure 3.1, a 16 ft. long steel beam was bolted to the strong floor. The top surface of the beam was free from rust and paint. Figure 3.2 shows the top of the steel sliding surface.

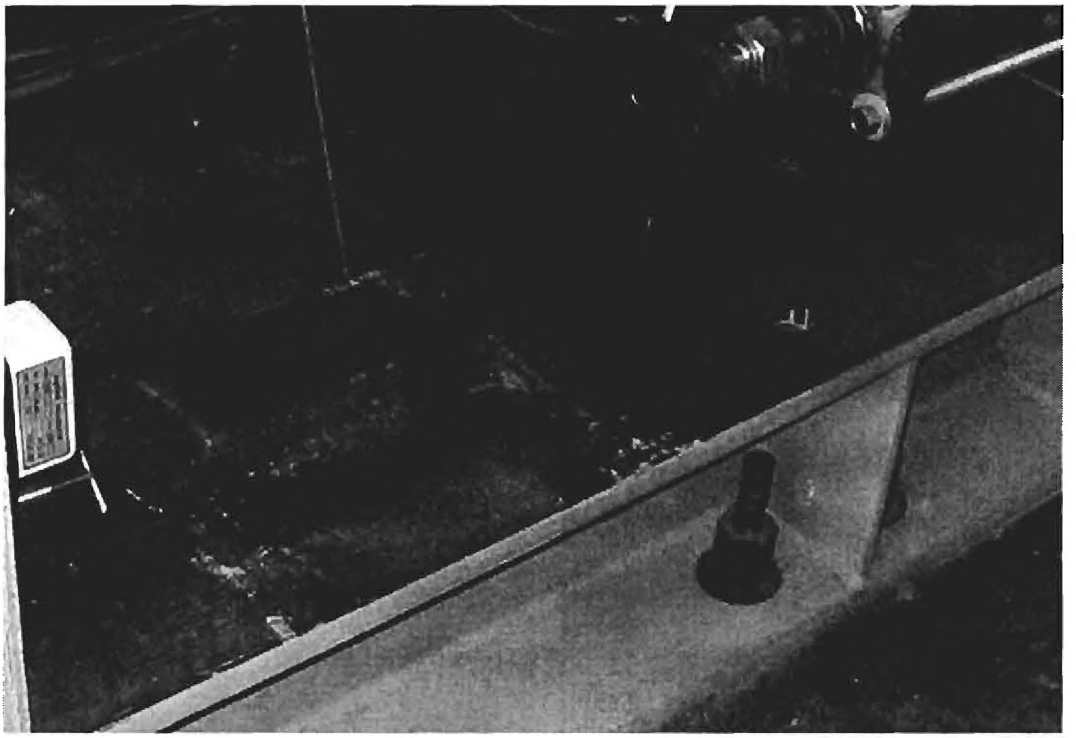


Figure 3.2 Steel sliding surface

The top flange was 15 in. wide, which was wide enough to ensure a stable motion of the concrete blocks. The concrete for the blocks was provided by Standard Concrete Products. The concrete block was pushed along the steel beam by a Power Team, 10 in. stroke, hydraulic ram. A short column was bolted to the end of one side of the beam for the hydraulic ram to be connected to. The concrete block's displacement was recorded by two string potentiometers connected to each top corner of the block and linear variable displacement transducer (LVDT) at the bottom middle of the block.

3.3 Instrumentation

The load cell used to record the applied load was an Interface 500 pound load cell, model no. SM-500. The load cell was a full-bridge configuration that required an excitation voltage of 10 volts direct current (DC).

The string potentiometer used to measure movement of the concrete block was a Rayelco Position Transducer, model P2-A, 10 volts DC excitation.

The LVDT was manufactured by the Trans-Tek, model number 0245-0000, serial no. J-91, and allowed for 6 inches of displacement.

The three linear displacement transducers were used as a check for one another. The two string potentiometers on each side of the concrete block were averaged to approximately know the displacement at the center of the block. The LVDT at the bottom of the block was placed approximately at the center of the block and was compared to the average potentiometer values.

3.4 Data Acquisition System

All instrumentation discussed in Section 3.3 was wired to a National Instruments data acquisition (DAQ) system. The DAQ system used was a SCXI-1000 Chassis, which a SCXI-1520 terminal block was connected into. Each transducer was wired into the SCXI-1520 terminal block. The terminal block contained 8 channels numbered 0 through 7. The load cell was wired in channel 0, the first string potentiometer (pot1) was wired into channel 1, the second string potentiometer (pot2) was wired into channel 2, and the LVDT was wired into channel 3. Figure 3.3 shows the DAQ system set up in the laboratory.

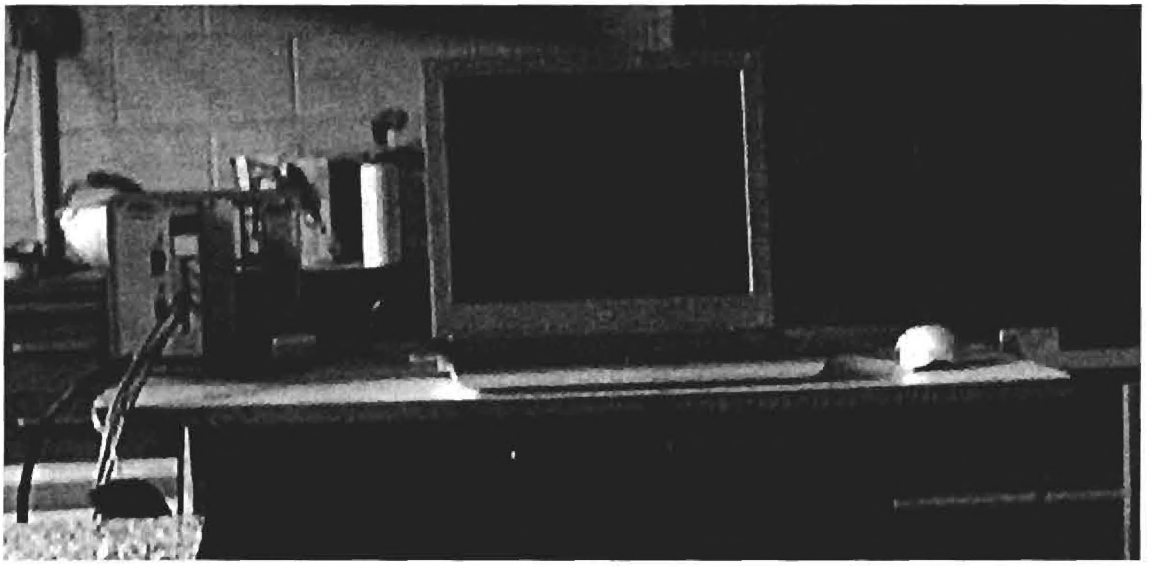


Figure 3.3 Labview DAQ system and laptop computer

3.5 Concrete Blocks

Each concrete block was 26 in. wide by 16 in. deep by 16 in. long with a ¾ in. chamfer at both base corners to imitate the bearing end of a BT-72 Type IV AASHTO bridge girder. Figure 3.4 shows a cross section of the concrete block. Two concrete block specimens were used for the experiment. One block was poured with the embedded steel plate shown in Figure 3.5 and 3.6, and the other block was plain concrete. The block with the steel embedded plate weighed 598.5 lbs., and the block with just concrete weighed 563 lbs.

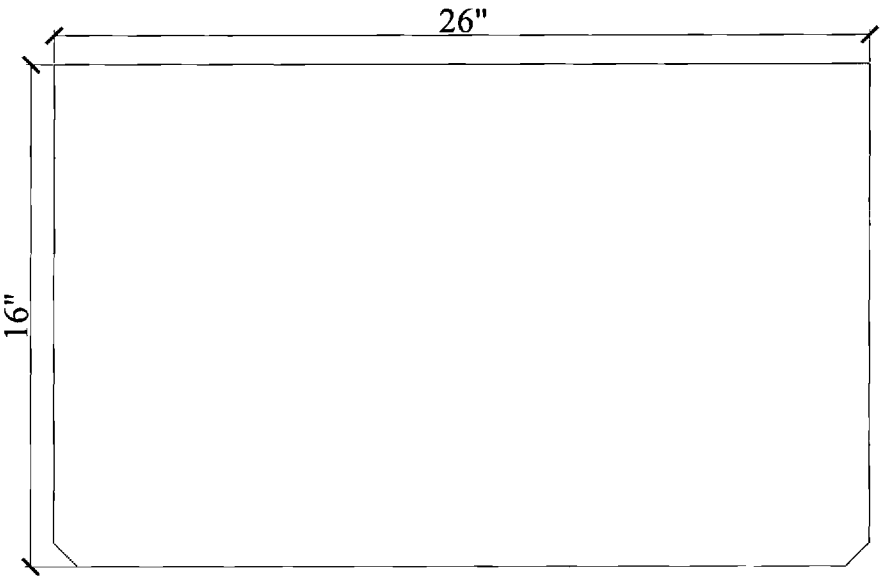
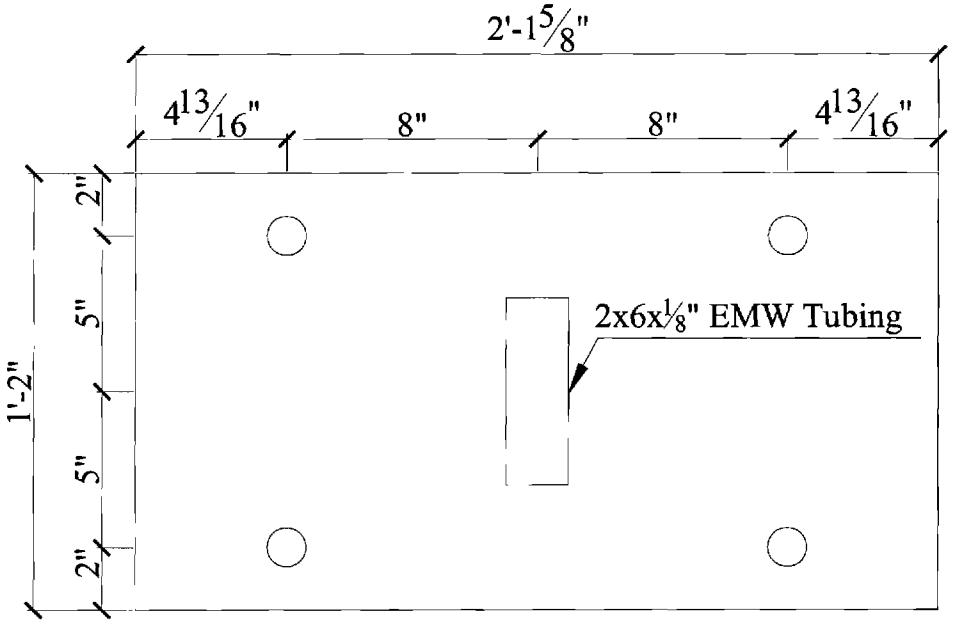


Figure 3.4 Cross section of concrete block



PLAN VIEW

Figure 3.5 Plan view of embedded steel plate

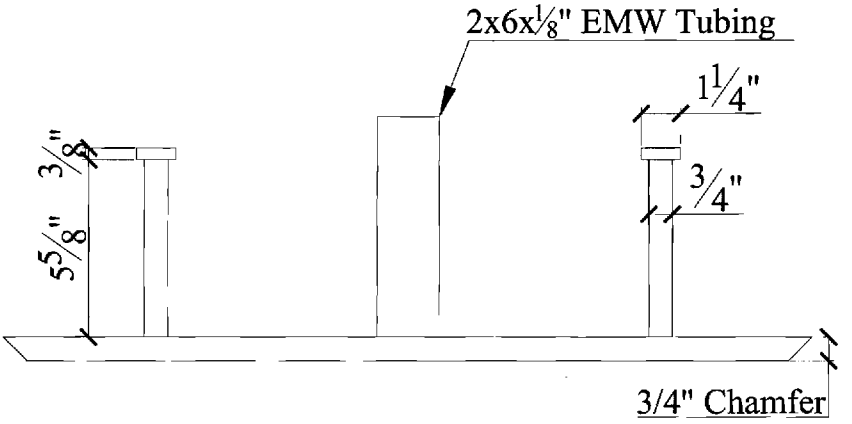


Figure 3.6 End view of embedded steel plate

3.6 Experiment Procedure

In order to find the coefficient of static friction for the five test specimens, the concrete block with a specified end treatment was pushed horizontally along the top flange of a steel beam.

The center of the loading ram was placed at 9 ¼" inches above the top flange. This distance was determined by knowing the self weight of the concrete block, 563 pounds. The coefficient of friction for the controlling case of concrete on bare steel is $\mu = 0.70$, which is the assumed valued used by ACI[2]. Summing the moments about the over-turning point on the concrete block enables the maximum allowable lever arm for the lateral force to be solved for. Figure 3.7 shows the free body diagram to solve for the maximum lever arm.

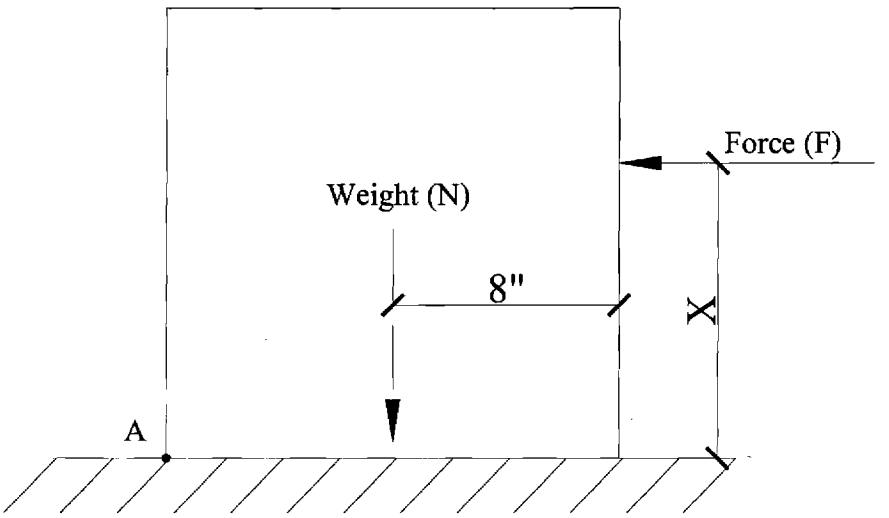


Figure 3.7 Free body diagram of maximum lever arm

$F = \mu N$

$F = 0.70*(563\ lb)$

$F = 394.1\ lb$

$\Sigma M_A = 0$

$F*x - N*(8") = 0$

$x = (563\ lb*8")/(394.1\ lb)$

$x = 11.43"$

The case of concrete on bare steel yields the maximum distance the force can be applied without overturning, which was 11.43 in. from the bottom. In the cases of steel on steel and greased surfaces, the coefficient of friction decreases and increases the lever arm distance.

The two concrete blocks were used for six different tests. The plain concrete block was tested and was used as a benchmark to measure the effectiveness of the friction reducing techniques. The details for each specific test are explained in Chapter IV.

CHAPTER IV

FRICTION LABORATORY TEST RESULTS AND DISCUSSION

4.1 Introduction

This chapter discusses the results of the laboratory experiment to measure which of the six different friction reducing techniques required the least horizontal force to move the concrete block along the steel surface.

Friction experiments were performed to determine the coefficient of static friction between the concrete and steel bed surfaces. The tests performed consisted of specimens with the following friction reducing techniques: none (control), none with an oil coated surface, steel plate with dry steel beam, steel plate with and an oil coated beam surface, teflon pad, and a wax lubricant. Three tests were performed for each technique, except for the teflon pad which had four tests performed.

Data tables for initial readings, zeroed readings, and average potentiometer reading tables are provided in Appendix A. Initial reading tables were produced from the raw data given by the National Instruments DAQ system. Zeroed reading tables were created by taking the lowest reading, the first data reading, and subtracting that value from each data point taken during the test. The zeroed reading tables were used to construct the load vs. LVDT and load vs. average potentiometer graphs for each test, showing the true representation of data points given by the DAQ system. The average potentiometer reading tables were produced by adding pot1 and pot2 on the initial and zeroed reading tables, and dividing by two.

The coefficient of static friction, μ_s, was calculated for each individual test and for each friction reducing technique using the greatest value from the load cell produced during the test and dividing by the normal force of the block used in the test. The concrete block with no

embedded steel plate weighed 563 lbs. and the concrete block with the embedded steel plate weighted 598.5 lbs. The three individual values for μ_s were then averaged to better represent the performance of the friction reducing technique. Graphs for load vs. LVDT and load vs. average potentiometer were produced using the zeroed data points.

After the initiation of movement for the block, the required force to continue lateral movement decreased, this value is the coefficient of dynamic friction, μ_d. The blocks came to a stop at the end of each pump from the hydraulic jack, so several values of the required horizontal force to initially move the block were read. Since the value for static friction is greater than the value for dynamic friction, the graphs have a wave form to them, which should be represented to show the true response of the concrete block under horizontal load[5]. Graphs for load vs. LVDT and load vs. average potentiometer are shown in the individual end treatment sections and the summary table of μ_s values is in the Section 4.8.

4.2 Control

The control specimen received no friction reducing technique. It was used as a benchmark for the other techniques to be compared to. The maximum horizontal force required to move the concrete block was used to calculate the μ_s values for each of the three tests. The values of maximum force and μ_s were 268.55 lbs. and 0.477, 273.81 lbs. and 0.486, and 325.74 lbs. and 0.579 for tests 1, 2, and 3, respectively. The average μ_s value was 0.514. A summary table of maximum horizontal force, μ_s values for each test, and an average μ_s value for the end treatment is presented in Table 4.1 in Section 4.8. Graphs for load vs. LVDT and load vs. average potentiometer for each of the three tests are shown in Figures 4.1 through 4.6.

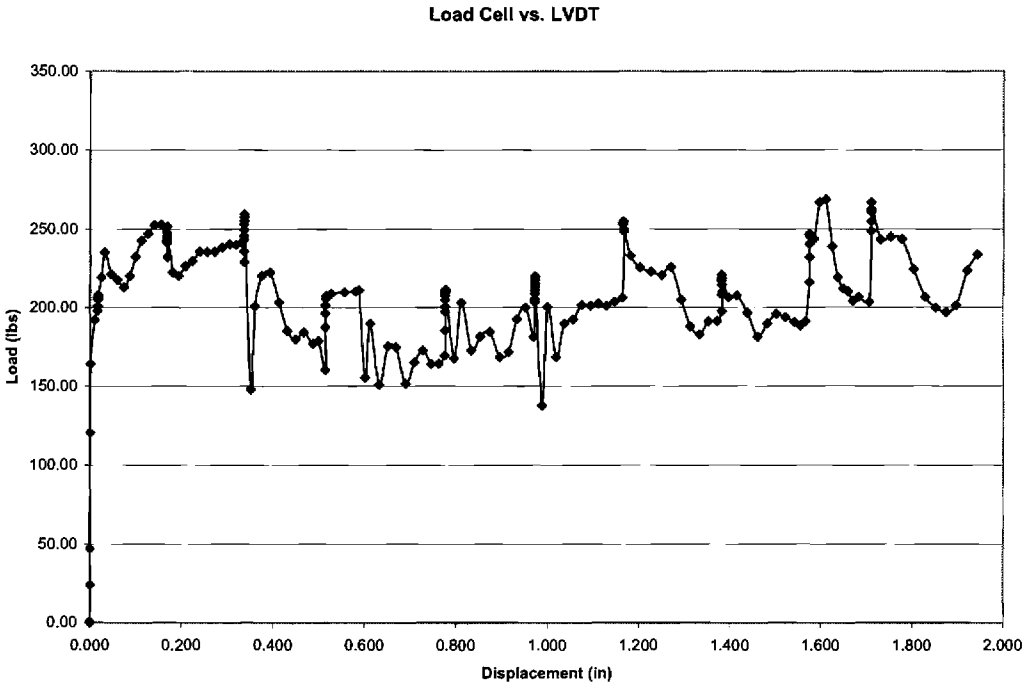


Figure 4.1 Load vs. LVDT for control test 1

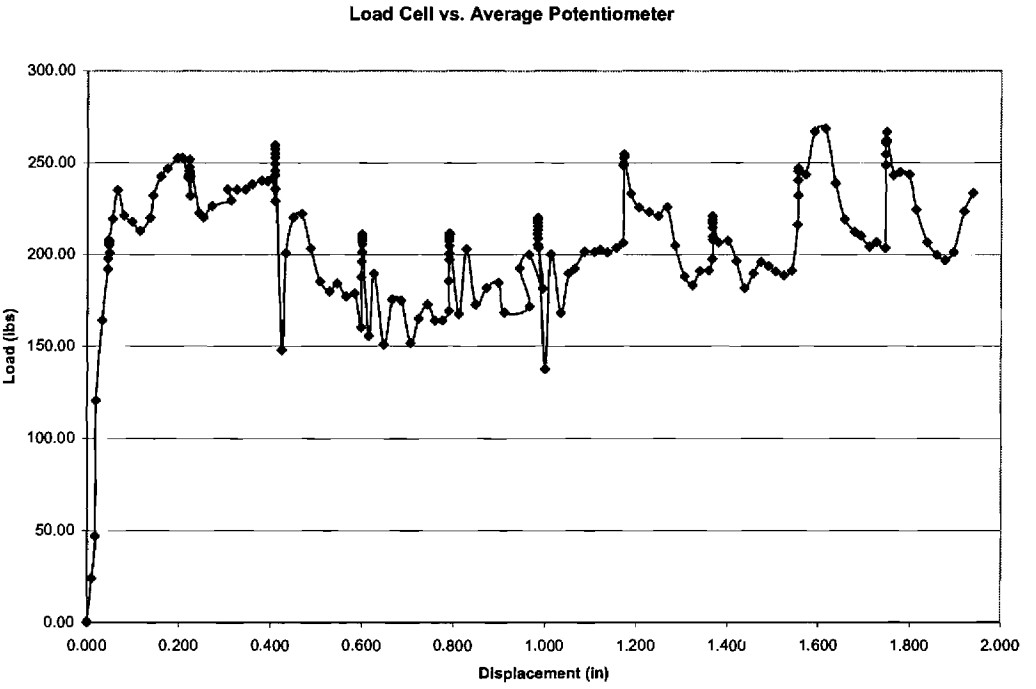


Figure 4.2 Load vs. average potentiometer for control test 1

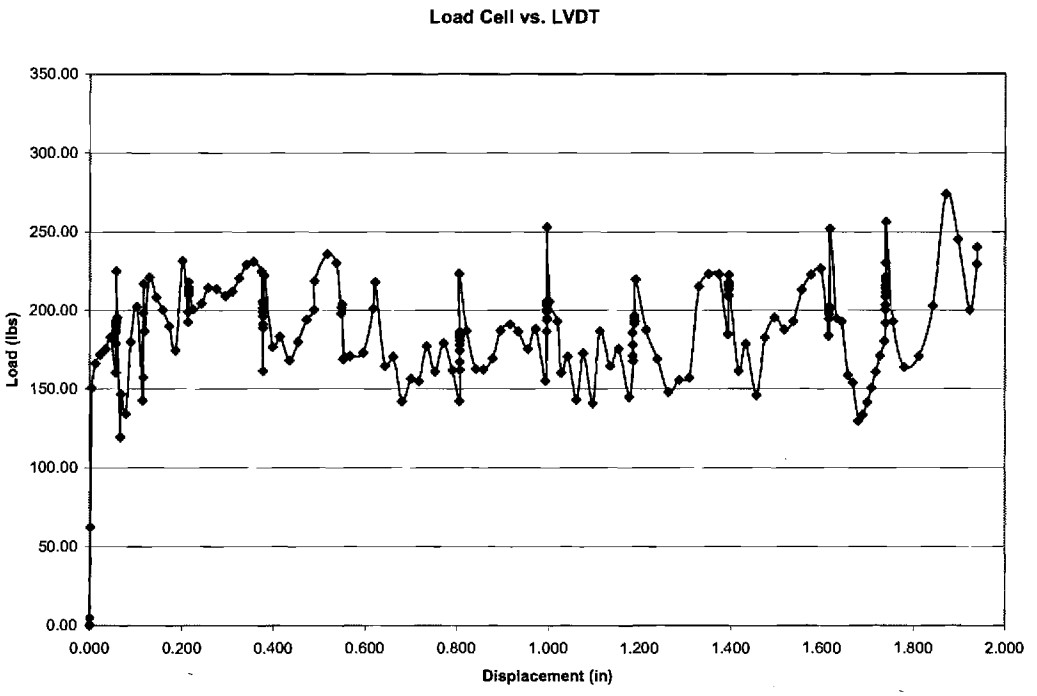


Figure 4.3 Load vs. LVDT for control test 2

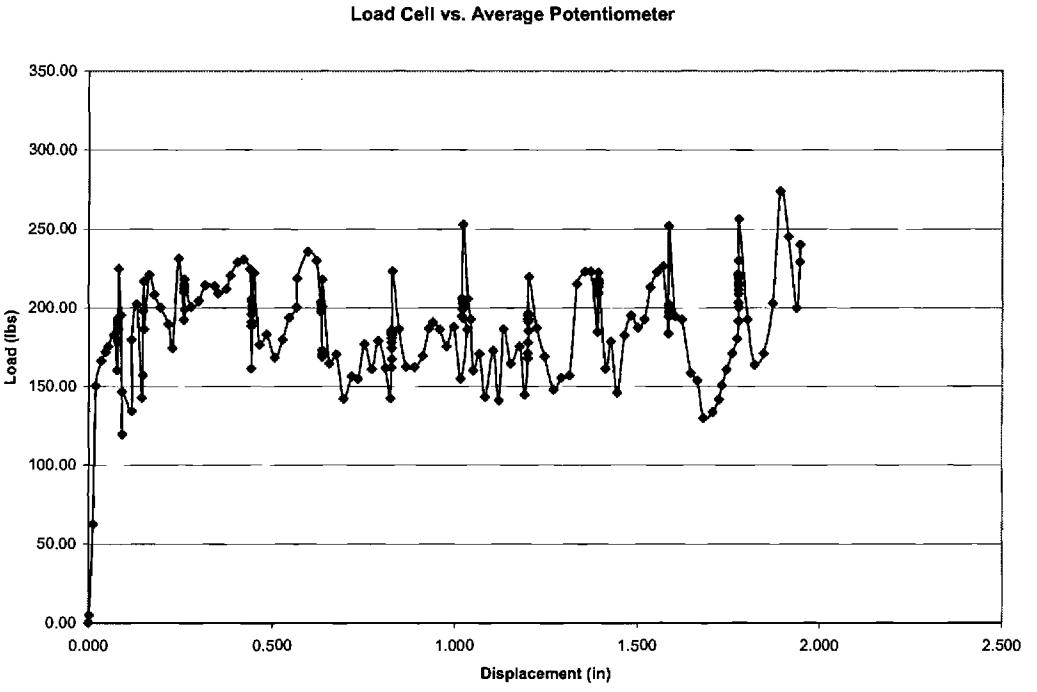


Figure 4.4 Load vs. average potentiometer for control test 2

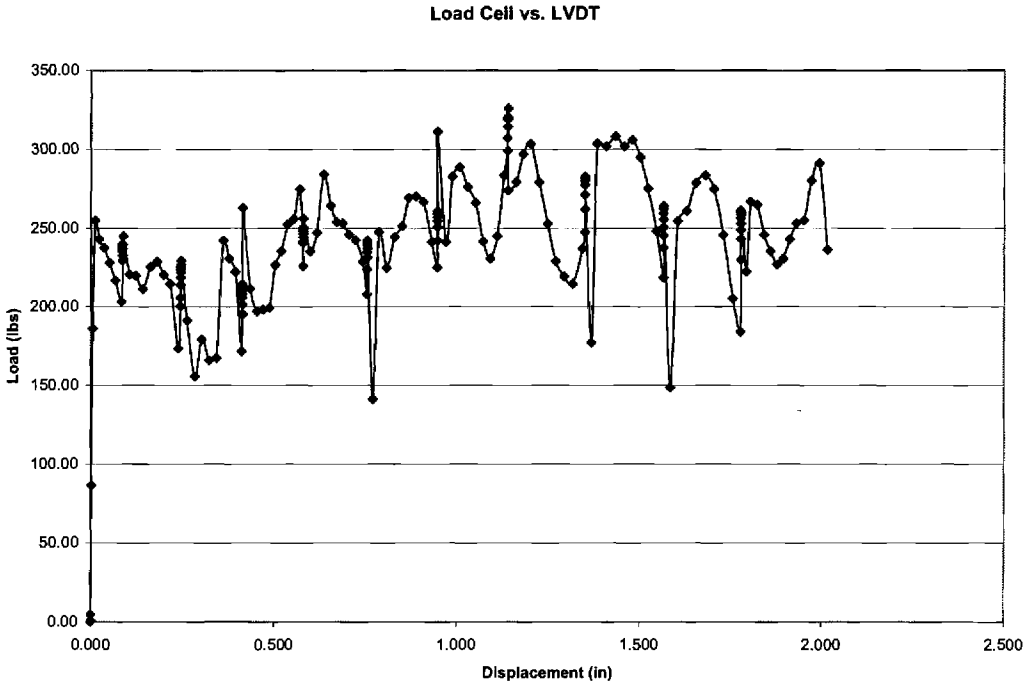


Figure 4.5 Load vs. LVDT for control test 3

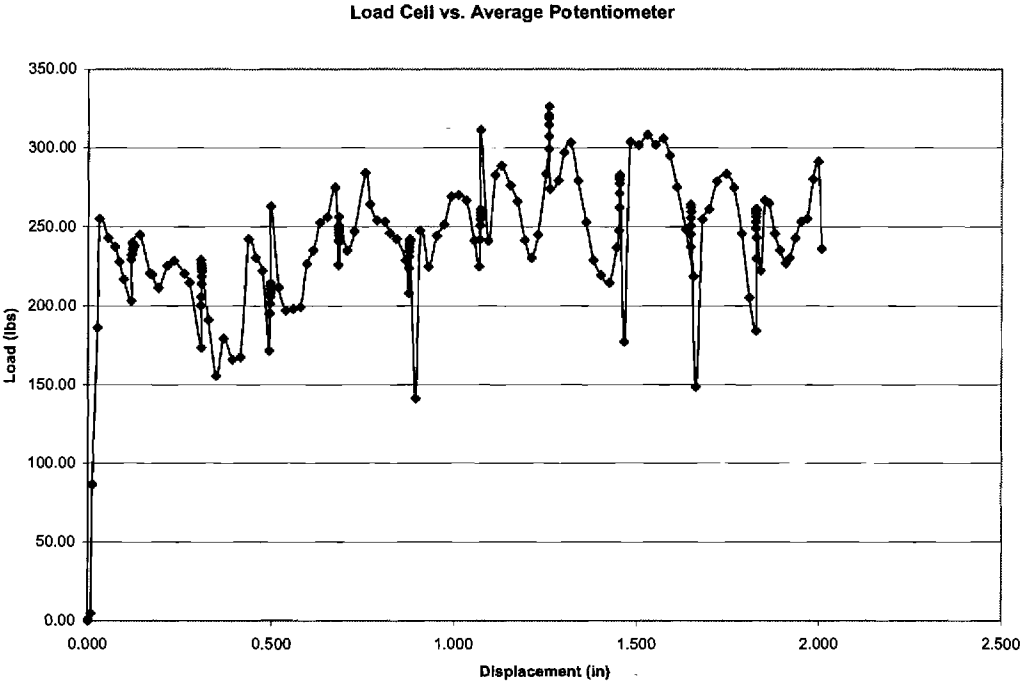


Figure 4.6 Load vs. average potentiometer for control test 3

4.3 Oil Lubricant

This test used the control block with the addition of a sliding surface covered in motor oil as a friction reducing lubricant shown in Figure 4.7. The maximum horizontal force required to move the concrete block was used to calculate the μ_s values for each of the three tests. The values of maximum force and μ_s were 261.06 lbs. and 0.464, 215.76 lbs. and 0.383, and 275.56 lbs. and 0.489 for tests 1, 2, and 3, respectively. The average μ_s value was 0.445. A summary table of maximum horizontal force, μ_s values for each test, and an average μ_s value for the friction reducing technique is presented in Table 4.1 in Section 4.8. Graphs for load vs. LVDT and load vs. average potentiometer for each of the three tests are shown in Figures 4.8 through 4.13.

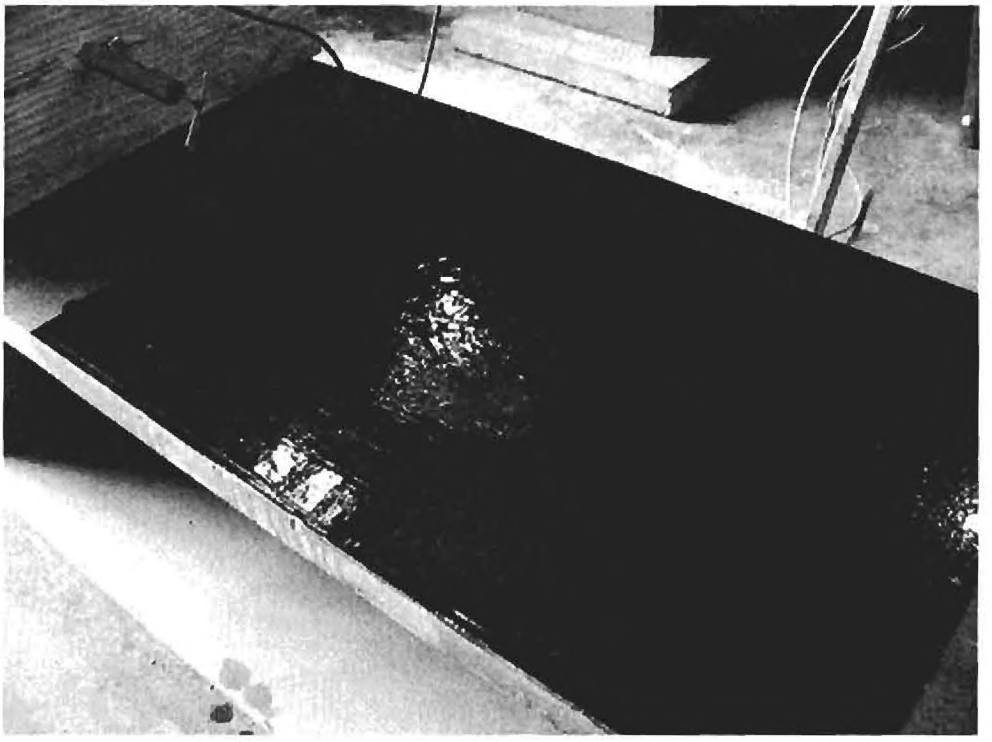


Figure 4.7 Steel surface coated with oil lubricant

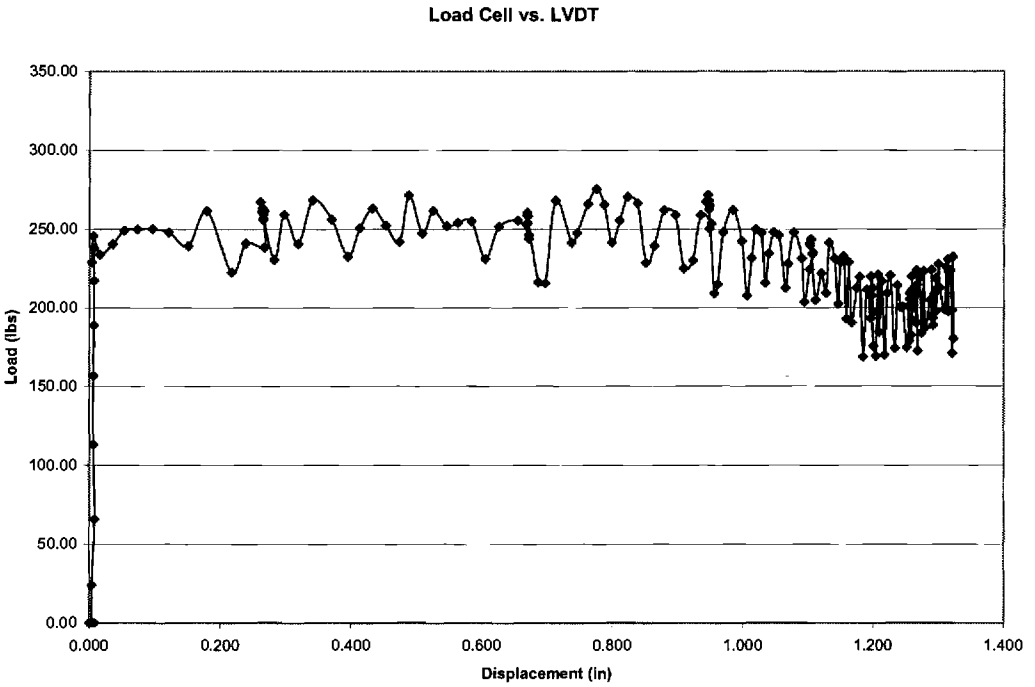


Figure 4.8 Load vs. LVDT for oil lubricant test 1

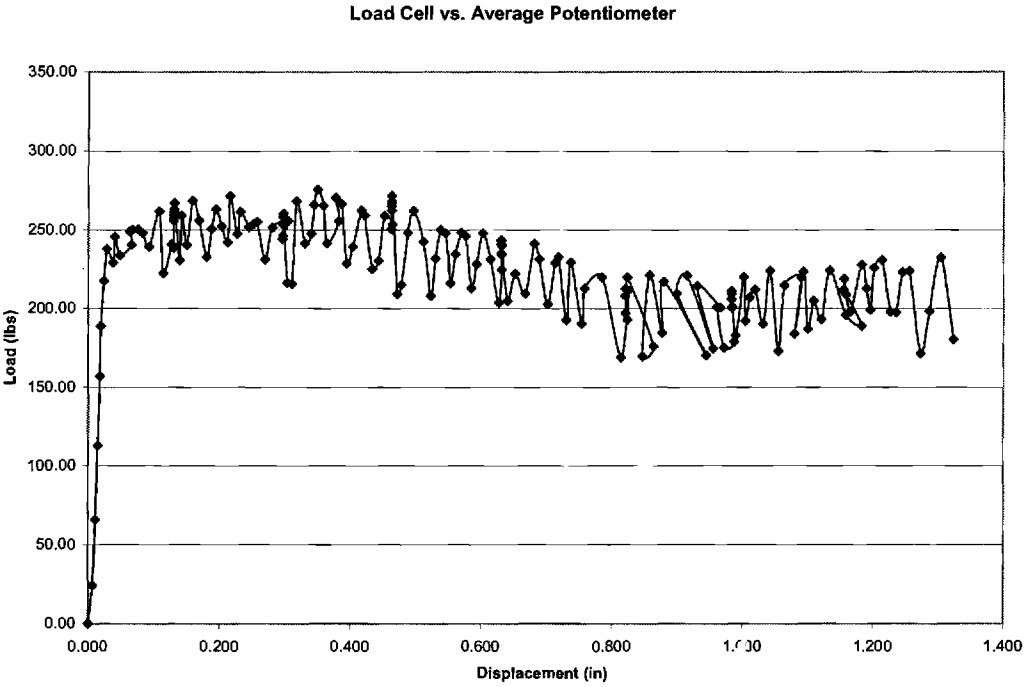


Figure 4.9 Load vs. average potentiometer for oil lubricant test 1

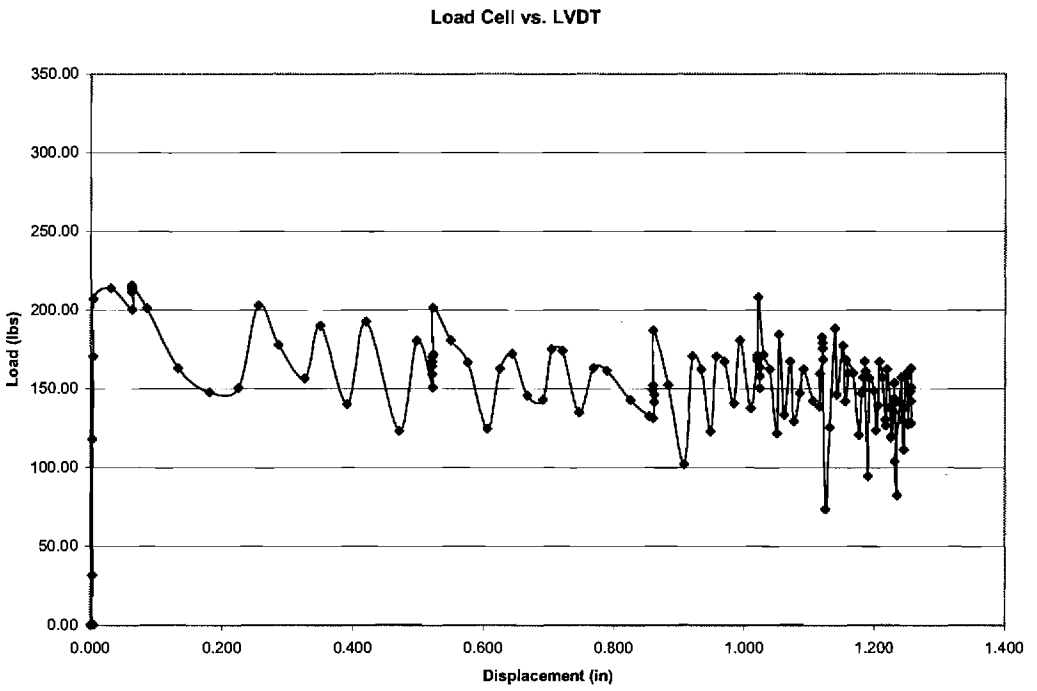


Figure 4.10 Load vs. LVDT for oil lubricant test 2

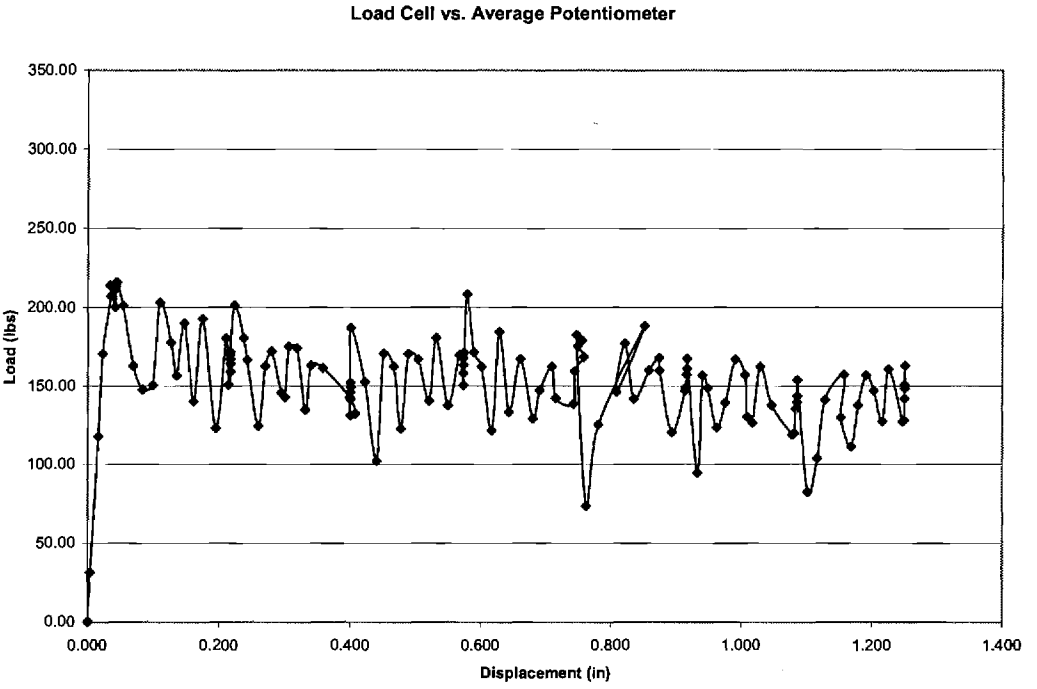


Figure 4.11 Load vs. average potentiometer for oil lubricant test 2

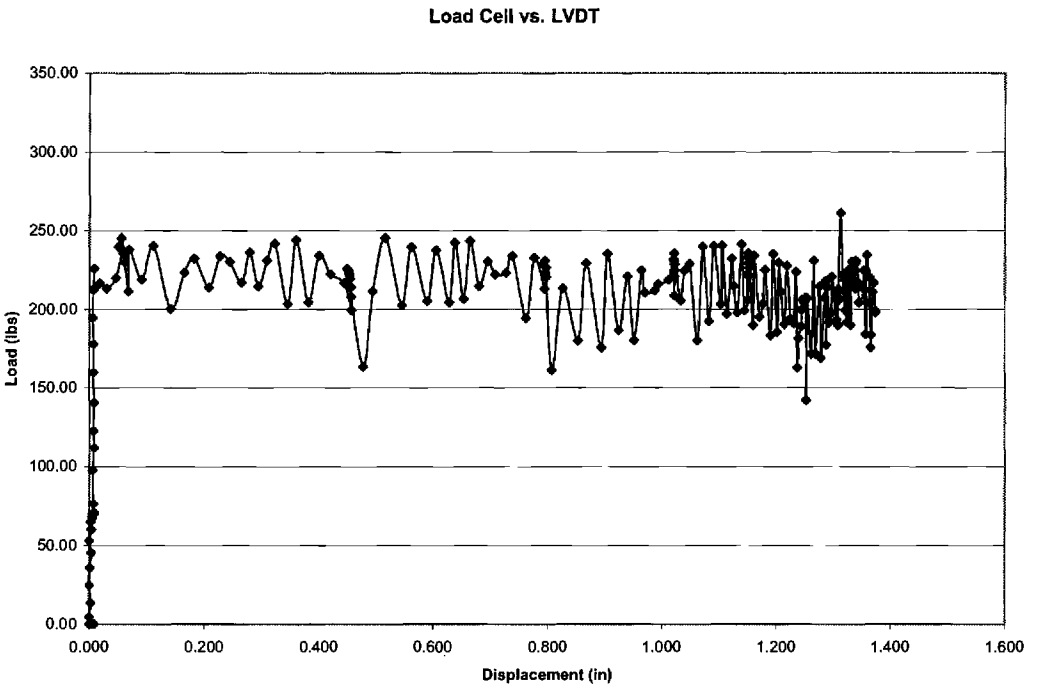


Figure 4.12 Load vs. LVDT for oil lubricant test 3

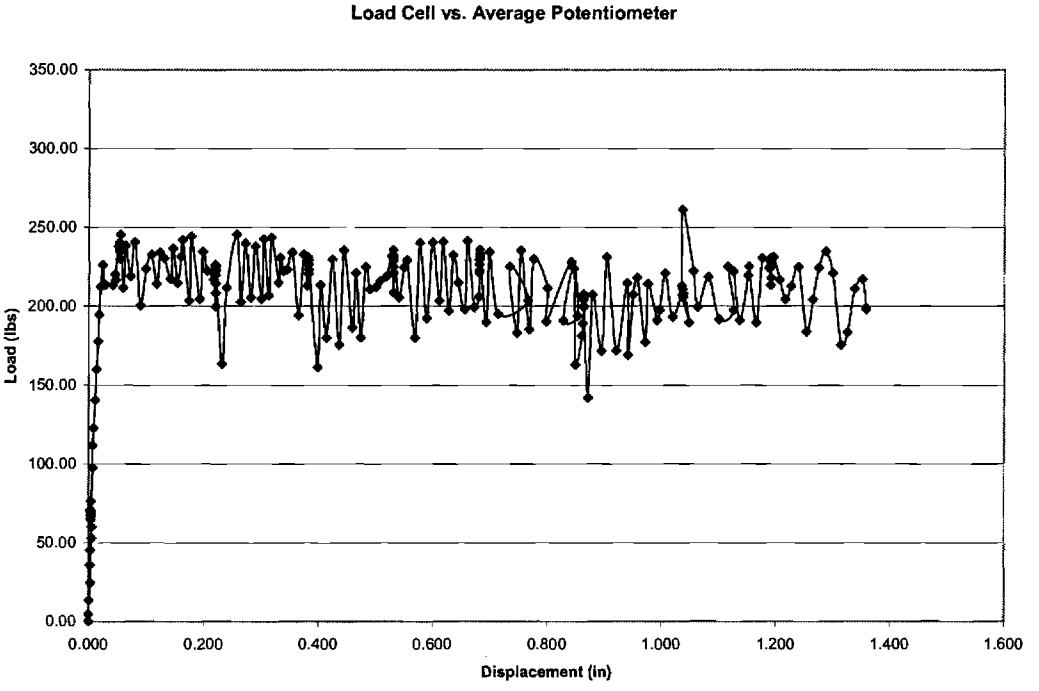


Figure 4.13 Load vs. average potentiometer for oil lubricant test 3

4.4 Teflon Pad

This test used the control block again with the addition of a magnetic teflon pad placed for the block to slide on; the same teflon pad has been used by Standard Concrete Products. The teflon pad was 14 in. in length and covered the full width of the steel beam as shown in Figure 4.14. The maximum horizontal force required to move the concrete block was used to calculate the μ_s values for each of the four tests. A fourth test was performed to check the validity of the test data for the first test. Due to the fact that the values for the first test were very much greater then those for the other three, the first test was viewed as an outlier and its μ_s value was not used in calculating the average μ_s value. Also, the graphs for load vs. LVDT and load vs. average potentiometer in tests 1, 3, and 4 exhibited an increase in required force to sustain motion. This is believed to have occurred since there was a quarter size chunk of concrete that existed on the bottom surface of the concrete. This chunk of concrete is believed to have dug into the teflon pad as the block was pushed horizontally as shown in Figure 4.15. Therefore, the first peak value of horizontal load was used as the required force to calculate maximum force and μ_s for the tests. The values of maximum force and μ_s were 229.61 lbs. and 0.408, 174.21 lbs. and 0.309, 108.71 lbs. and 0.193, and 164.19 lbs. and 0.292 for tests 1, 2, 3, and 4, respectively. The average μ_s value was 0.265. A summary table of maximum horizontal force, μ values for each test, and an average μ_s value for the end treatment is presented in Table 4.1 in Section 4.8. Figure 4.14 shows the teflon pad placed on the steel beam sliding surface and Figure 4.15 shows the teflon pad after the concrete block was pushed along its surface. Graphs for load vs. LVDT and load vs. average potentiometer for each of the four tests are shown in Figures 4.16 through 4.23.

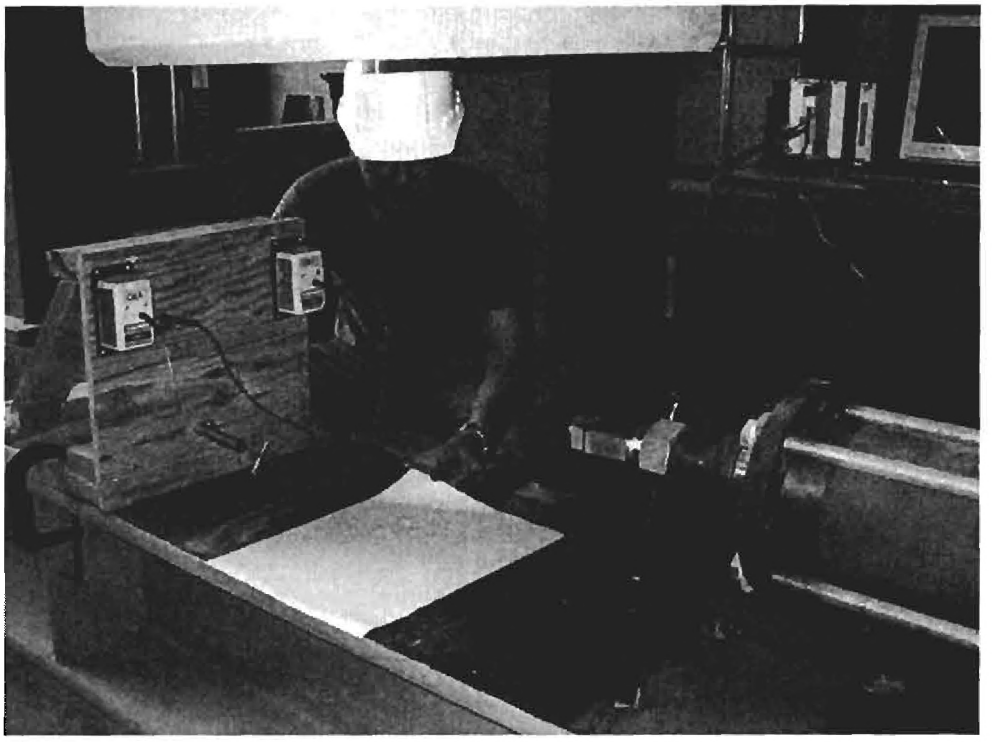


Figure 4.14 Teflon pad placed on steel sliding surface

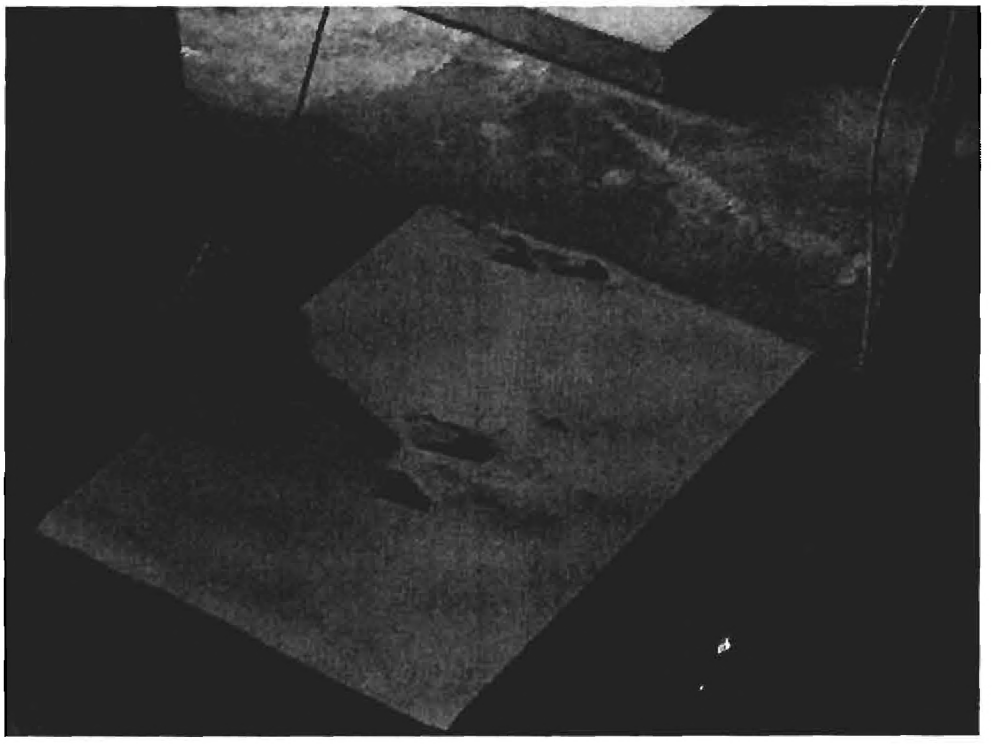


Figure 4.15 Teflon pad after concrete block tested

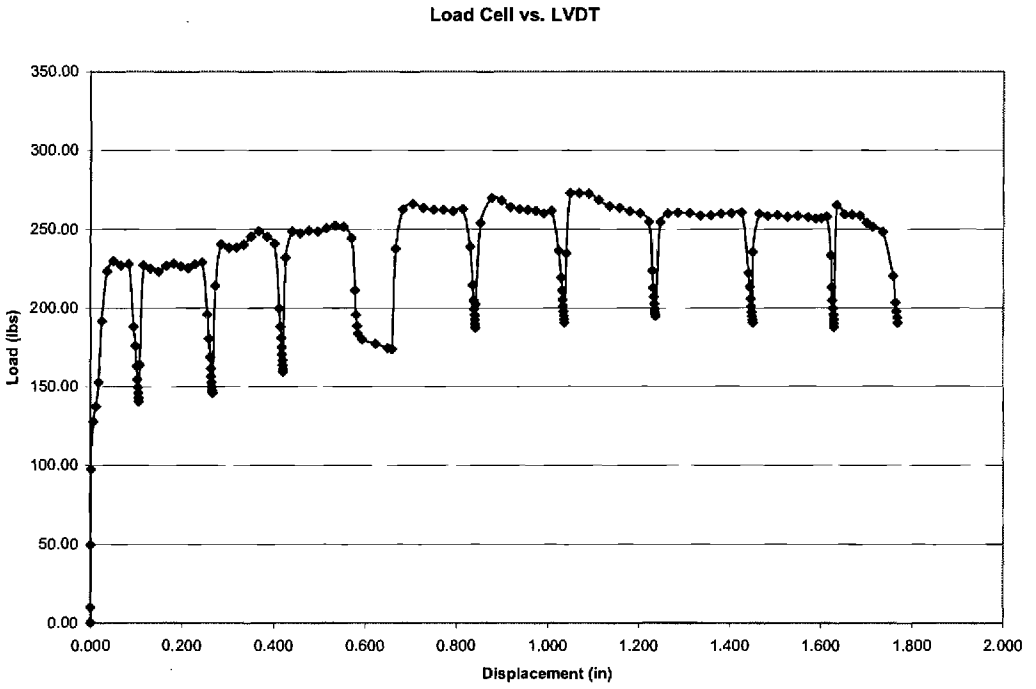


Figure 4.16 Load vs. LVDT for teflon pad test 1

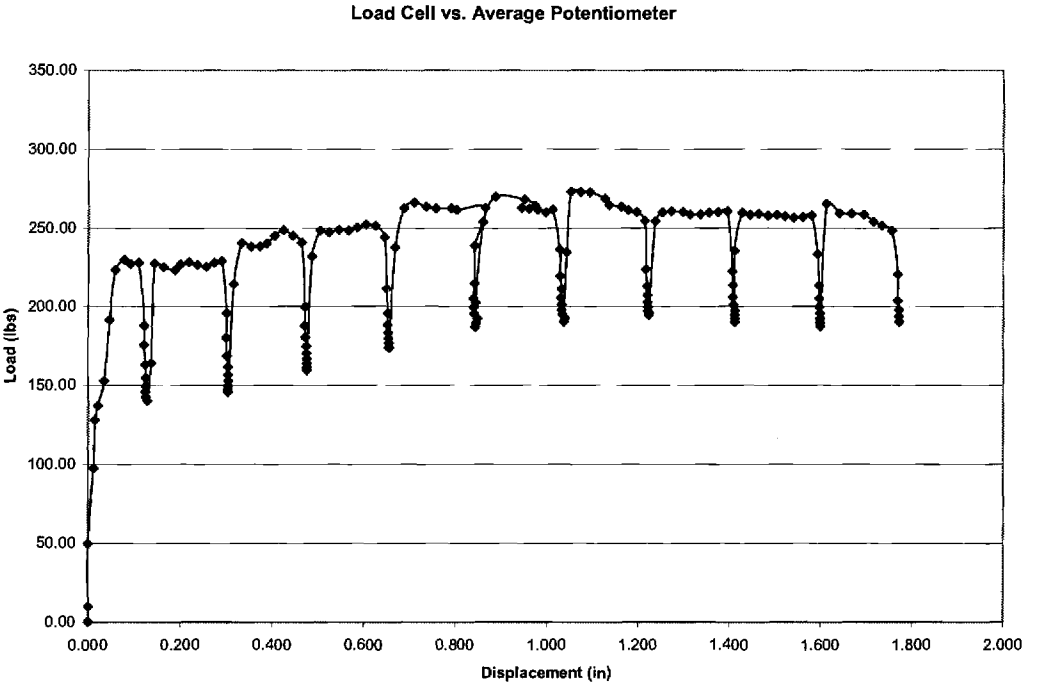


Figure 4.17 Load vs. average potentiometer for teflon pad test 1

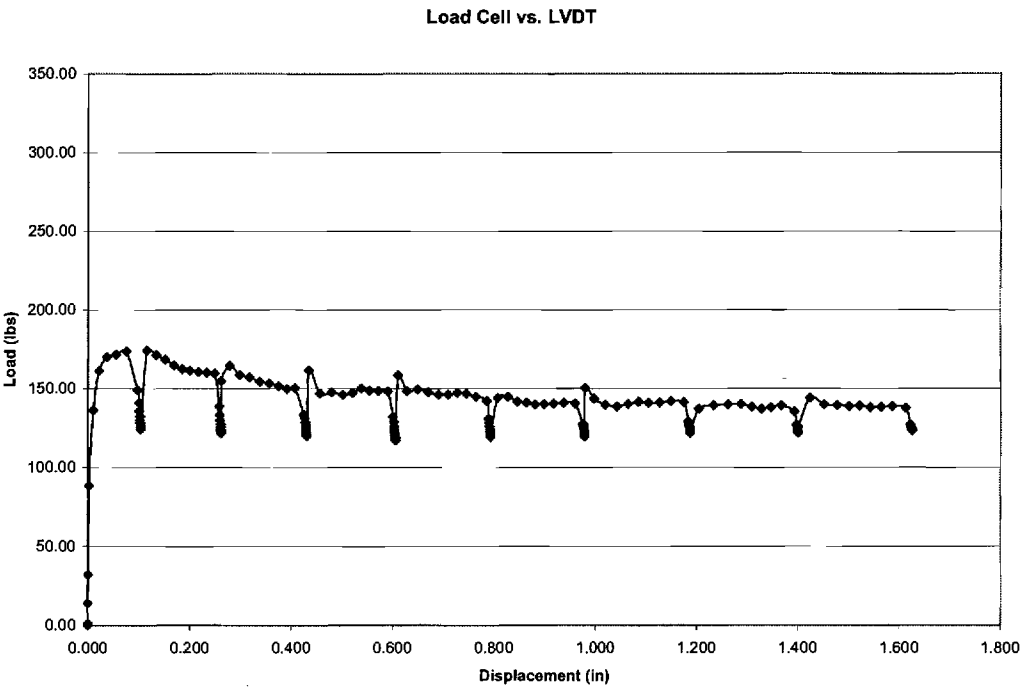


Figure 4.18 Load vs. LVDT for teflon pad test 2

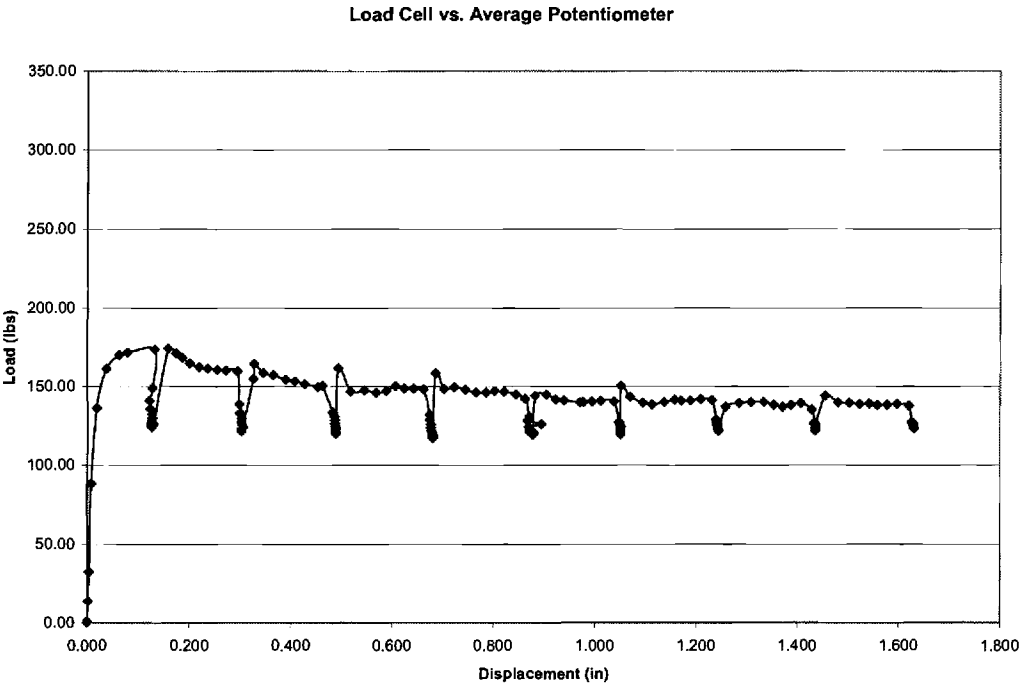


Figure 4.19 Load vs. average potentiometer for teflon pad test 2

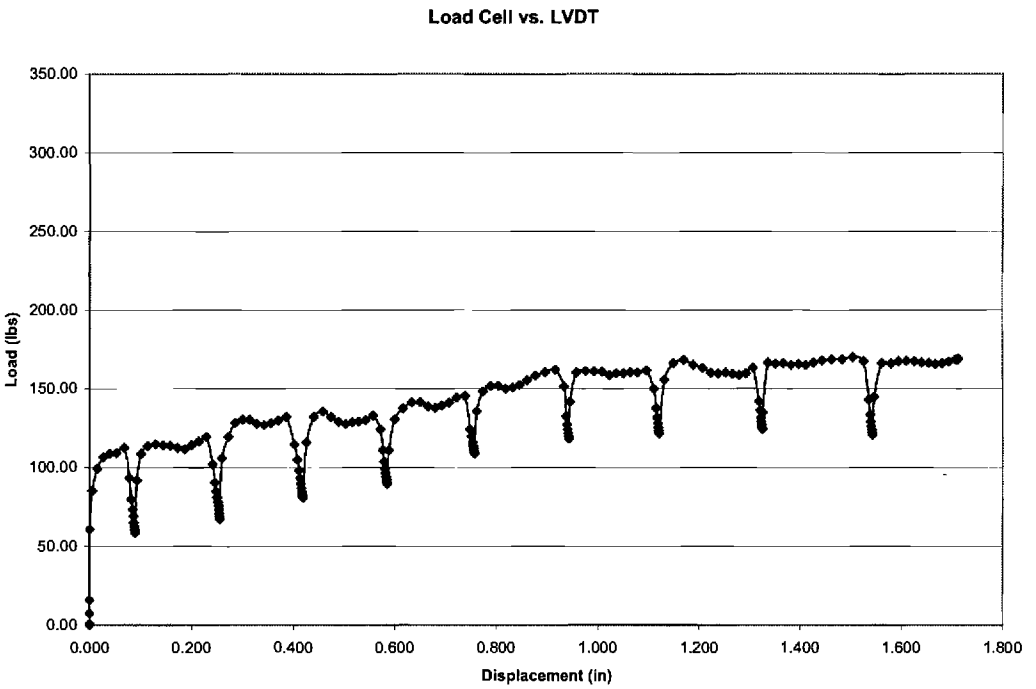


Figure 4.20 Load vs. LVDT for teflon pad test 3

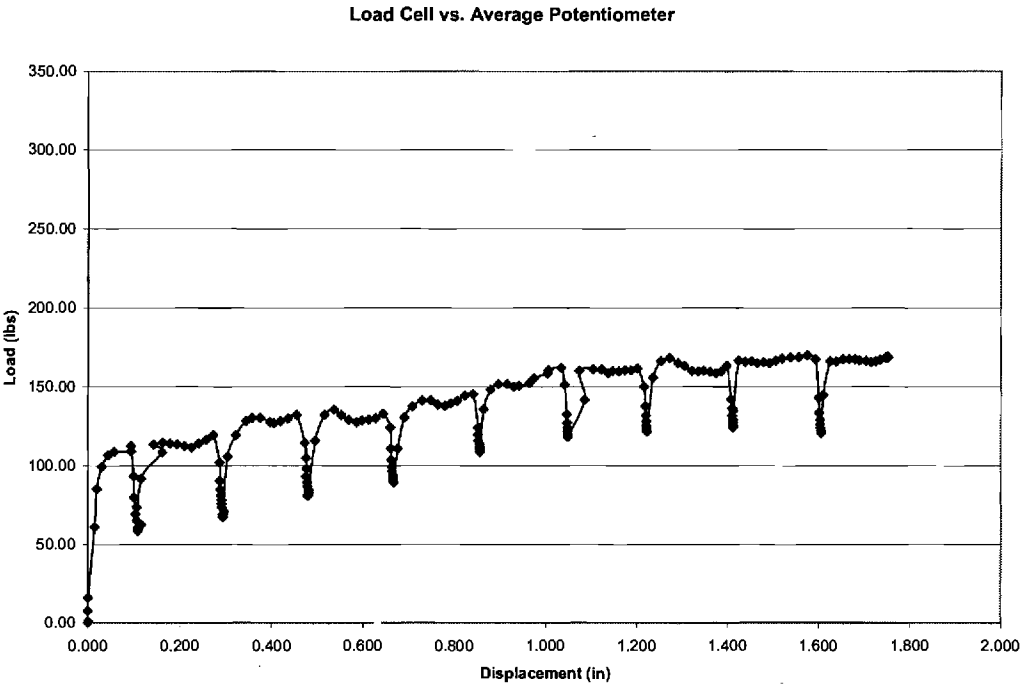


Figure 4.21 Load vs. average potentiometer for teflon pad test 3

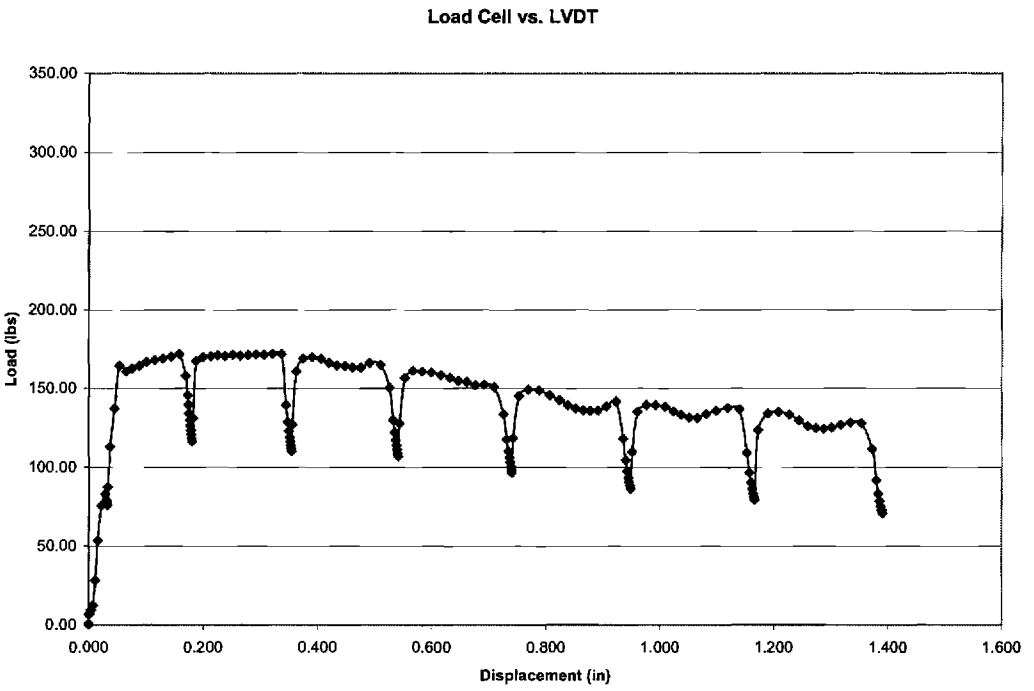


Figure 4.22 Load vs. LVDT for teflon pad test 4

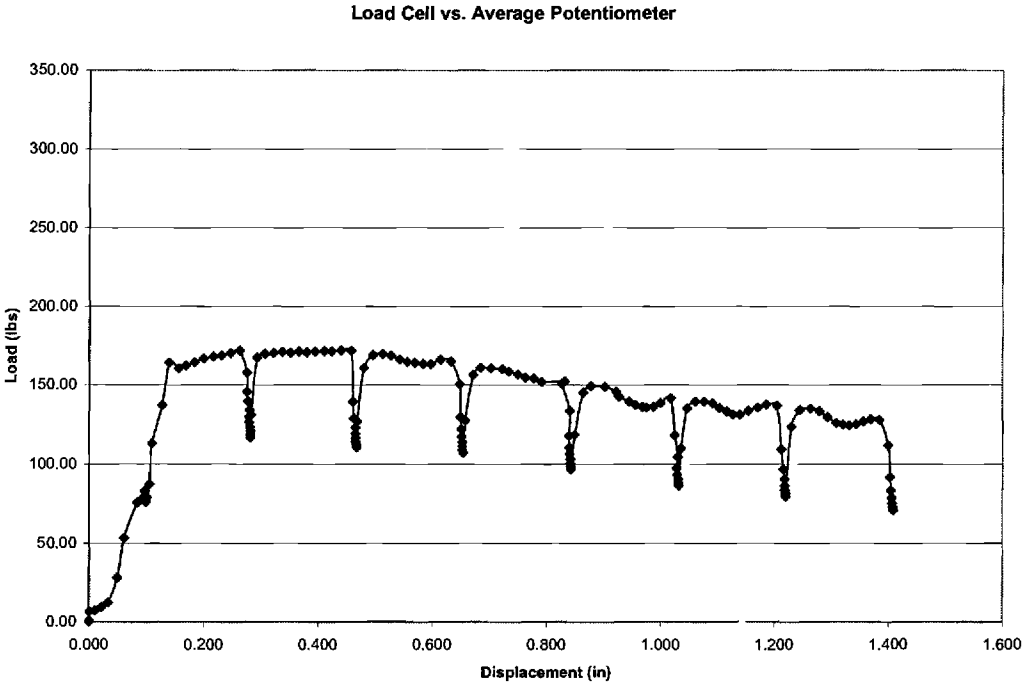


Figure 4.23 Load vs. average potentiometer for teflon pad test 4

4.5 Wax Lubricant

This test used the control block again with the addition of a wax luricant placed on the beam surface for the block to slide on. The wax lubricant, termed RA5840, was manufactured and provided by Cellulose Solutions of Dothan, Alabama. The maximum horizontal force required to move the concrete block was used to calculate the μ_s values for each of the three tests. The values of maximum force, in pounds, and μ_s were 127.02 lbs. and 0.226, 139.01 lbs. and 0.247, and 125.68 lbs. and 0.223 for tests 1, 2, and 3, respectively. The average μ_s value was 0.232. A summary table of maximum horizontal force, μ_s values for each test, and an average μ_s value for the end treatment is presented in Table 4.1 in Section 4.8. Graphs for load vs. LVDT and load vs. average potentiometer for each of the three tests are shown in Figures 4.24 through 4.29.

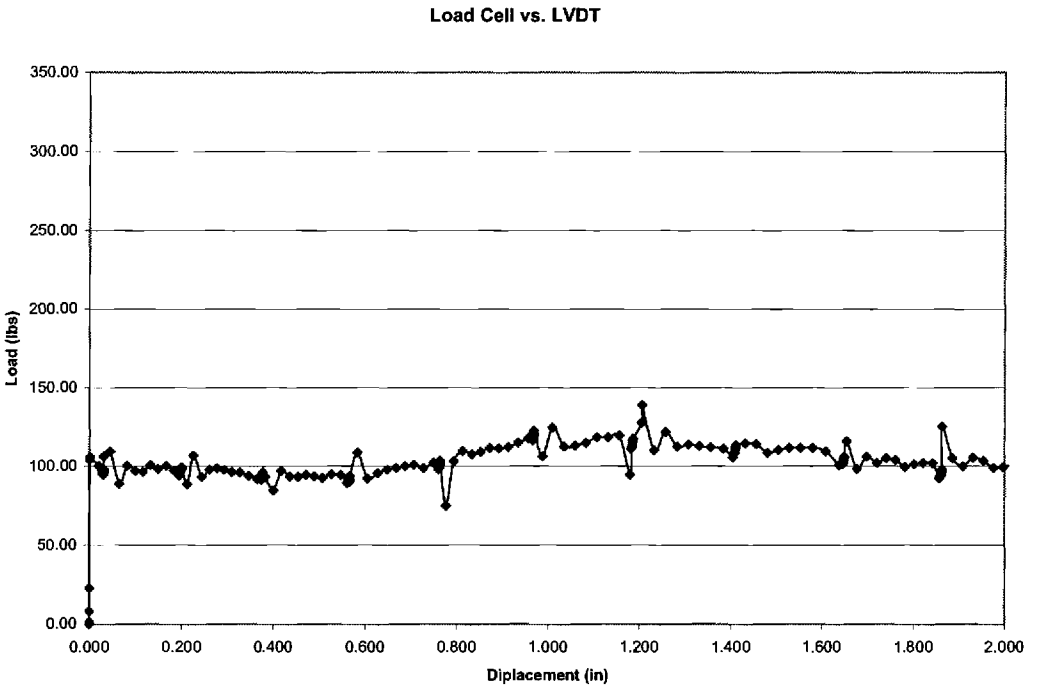


Figure 4.24 Load vs. LVDT for wax lubricant test 1

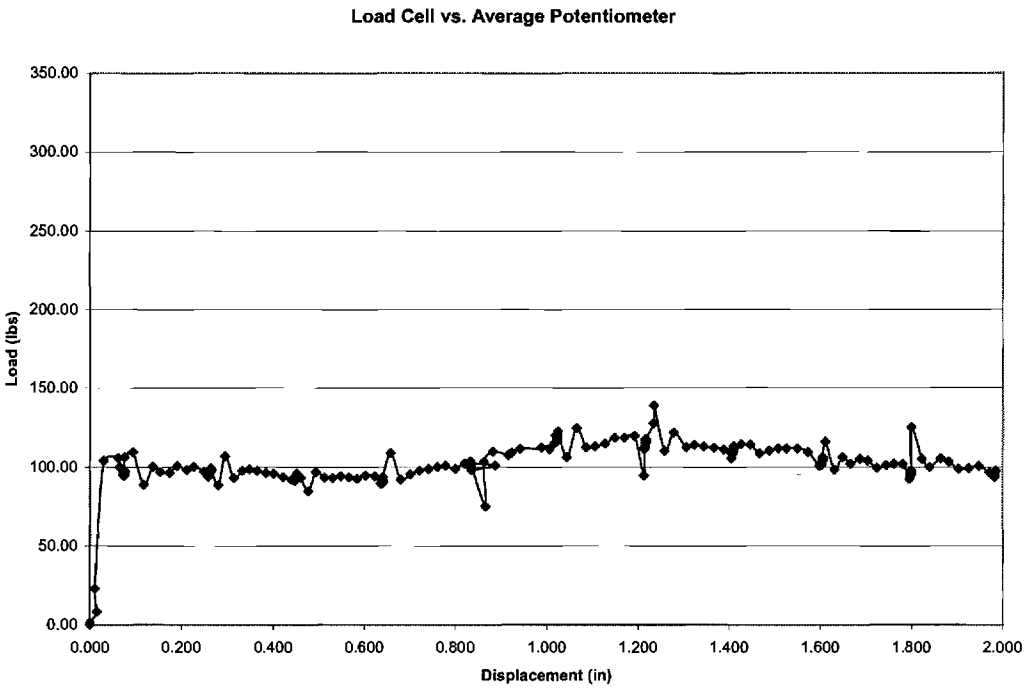


Figure 4.25 Load vs. average potentiometer for wax lubricant test 1

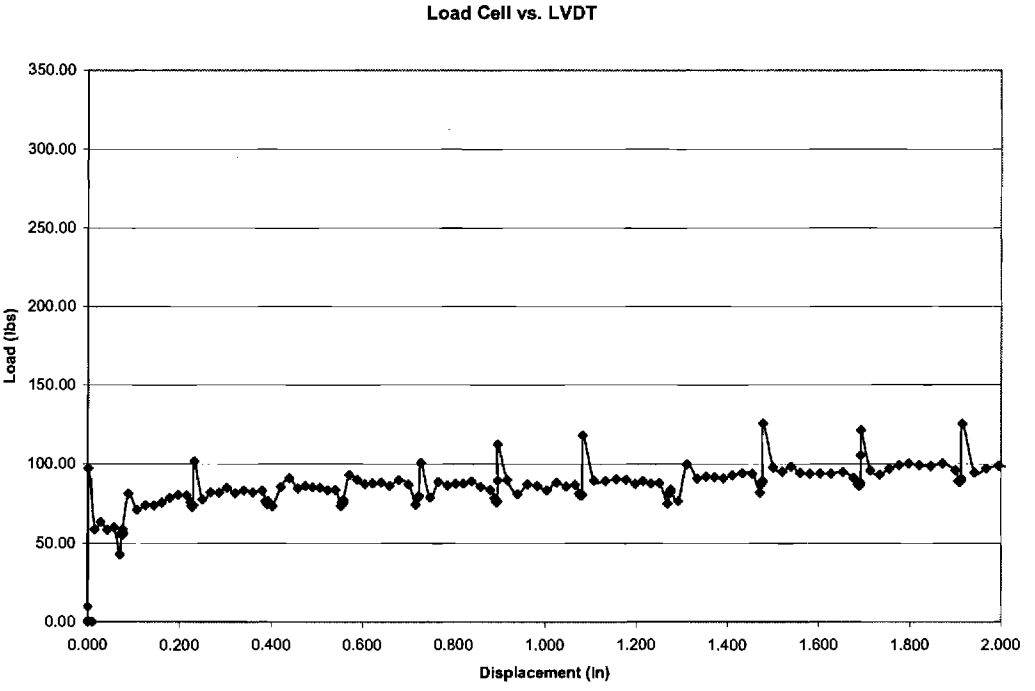


Figure 4.26 Load vs. LVDT for wax lubricant test 2

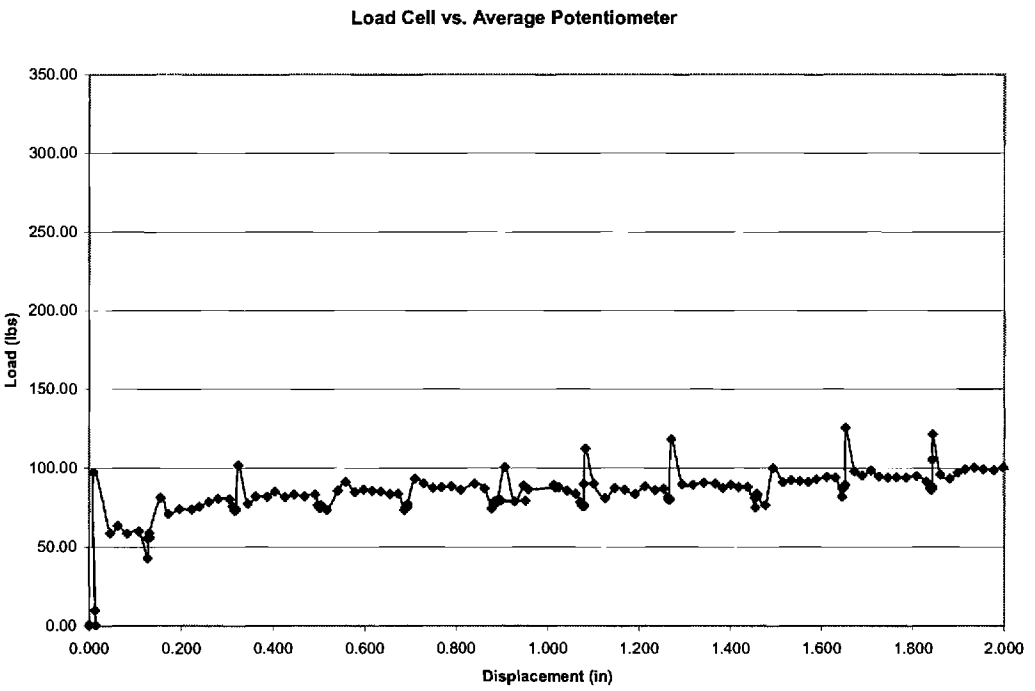


Figure 4.27 Load vs. average potentiometer for wax lubricant test 2

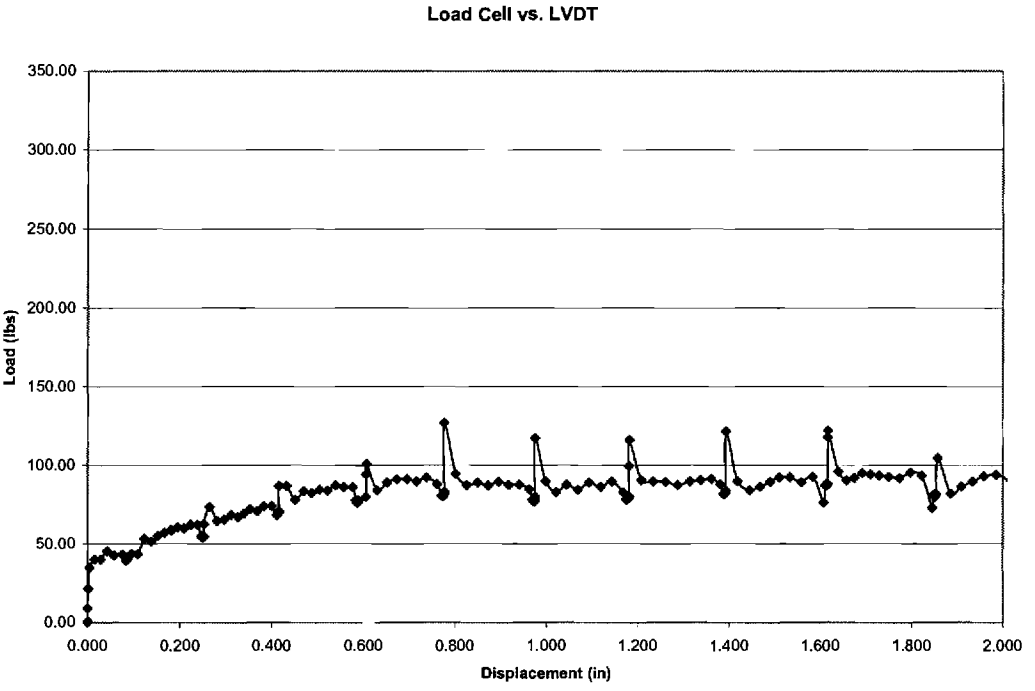


Figure 4.28 Load vs. LVDT for wax lubricant test 3

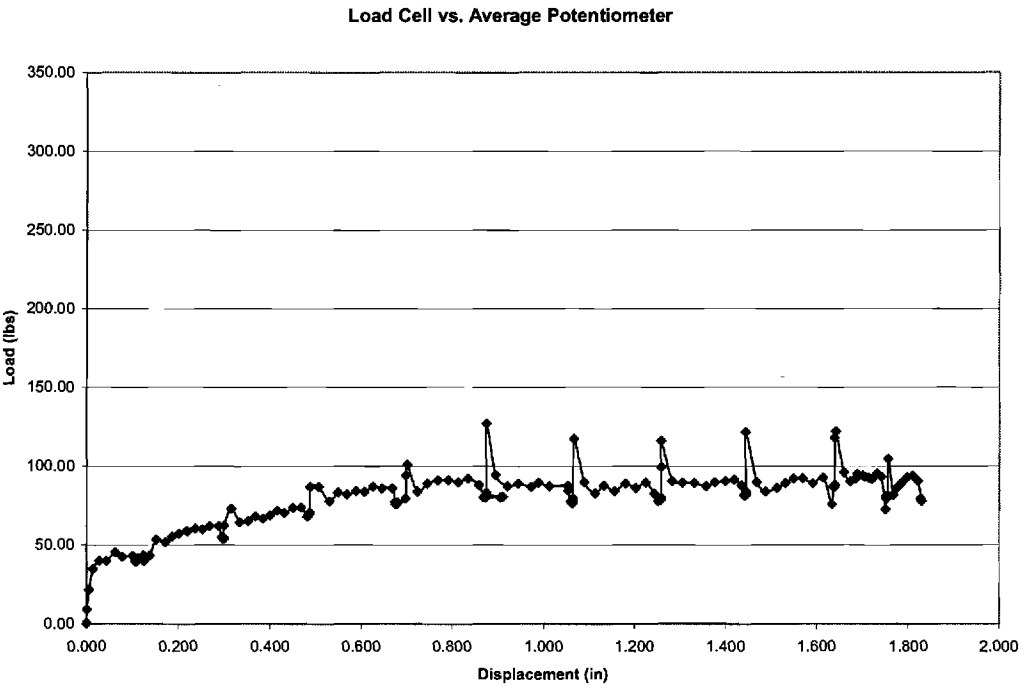


Figure 4.29 Load vs. average potentiometer for wax lubricant test 3

4.6 Steel Plate

The steel plate end treatment contained a concrete block with the steel embedment specified by the State of South Carolina Department of Transportation. Specifications for the embedded steel plate are shown in Figures 3.5 and 3.6. No oil was spread on the steel beam. The maximum horizontal force required to move the concrete block was used to calculate the μ_s values for each of the three tests. The values of maximum force and μ_s were 131.61 lbs. and 0.220, 135.43 lbs. and 0.230, and 137.41 lbs. and 0.226 for tests 1, 2, and 3, respectively. The average μ_s value was 0.225. A summary table of maximum horizontal force, μ_s values for each test, and an average μ_s value for the end treatment is presented in Table 4.1 in Section 4.8. Graphs for load vs. LVDT and load vs. average potentiometer for each of the three tests are shown in Figures 4.30 through 4.35.

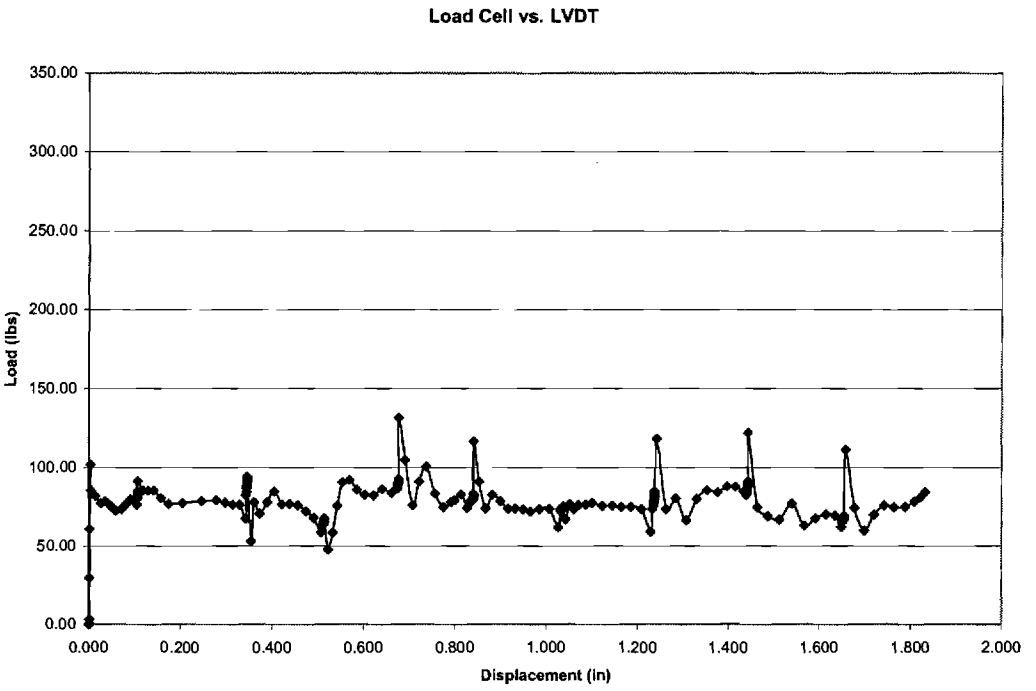


Figure 4.30 Load vs. LVDT for steel plate test 1

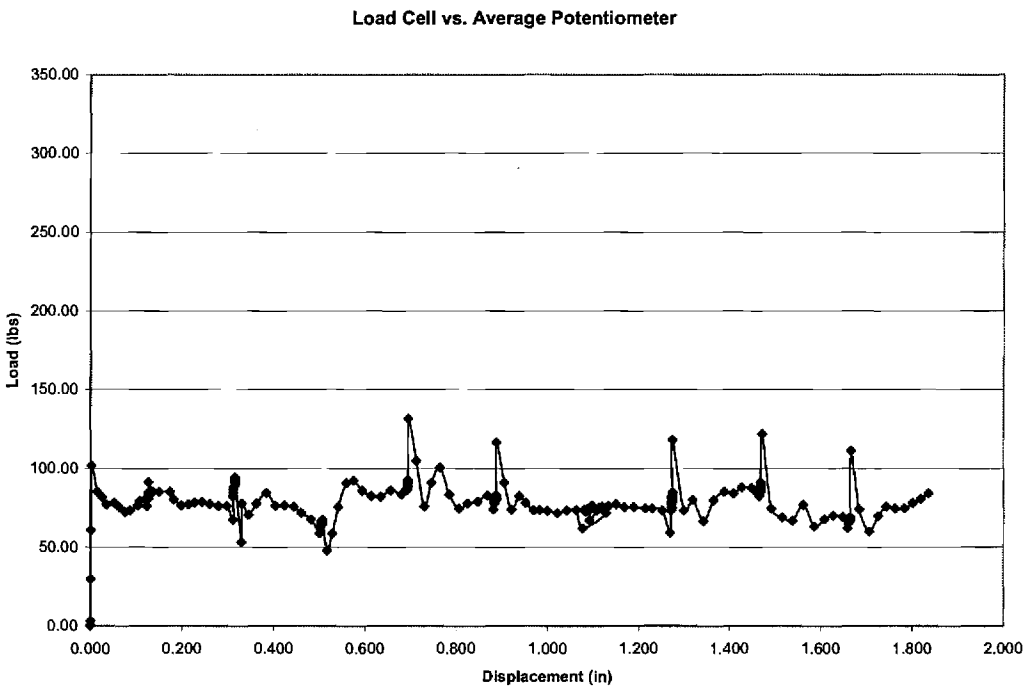


Figure 4.31 Load vs. average potentiometer for steel plate test 1

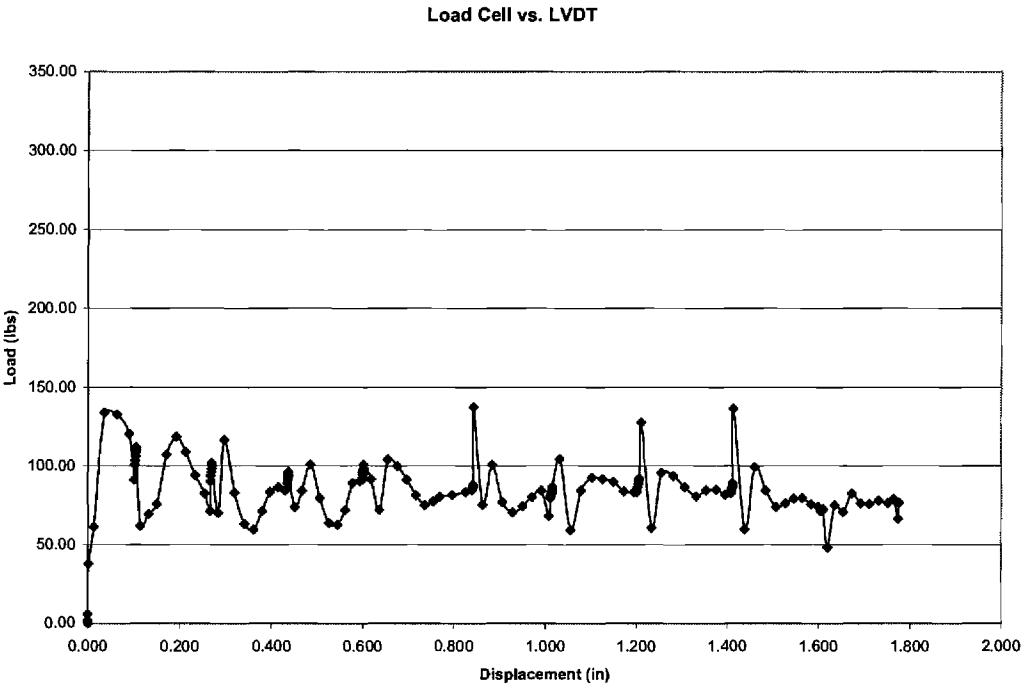


Figure 4.32 Load vs. LVDT for steel plate test 2

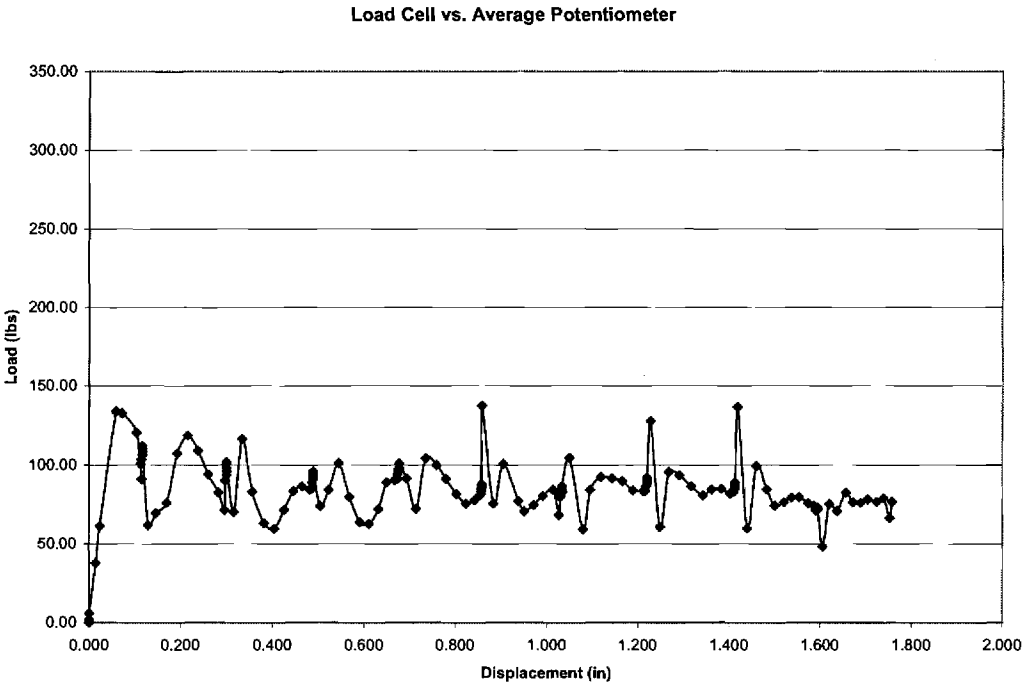


Figure 4.33 Load vs. average potentiometer for steel plate test 2

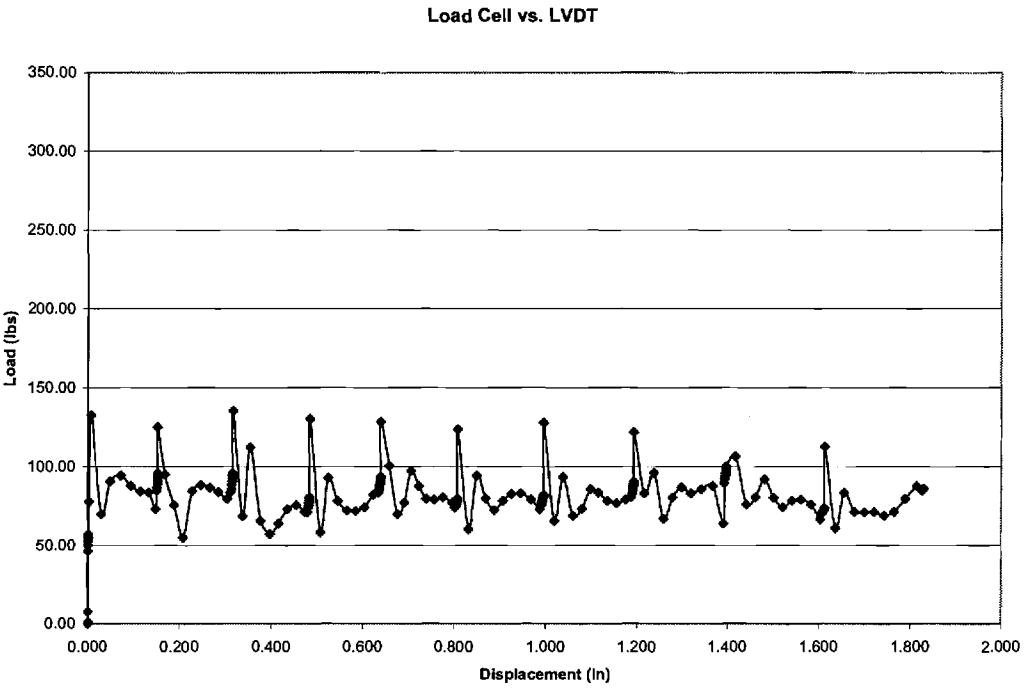


Figure 4.34 Load vs. LVDT for steel plate test 3

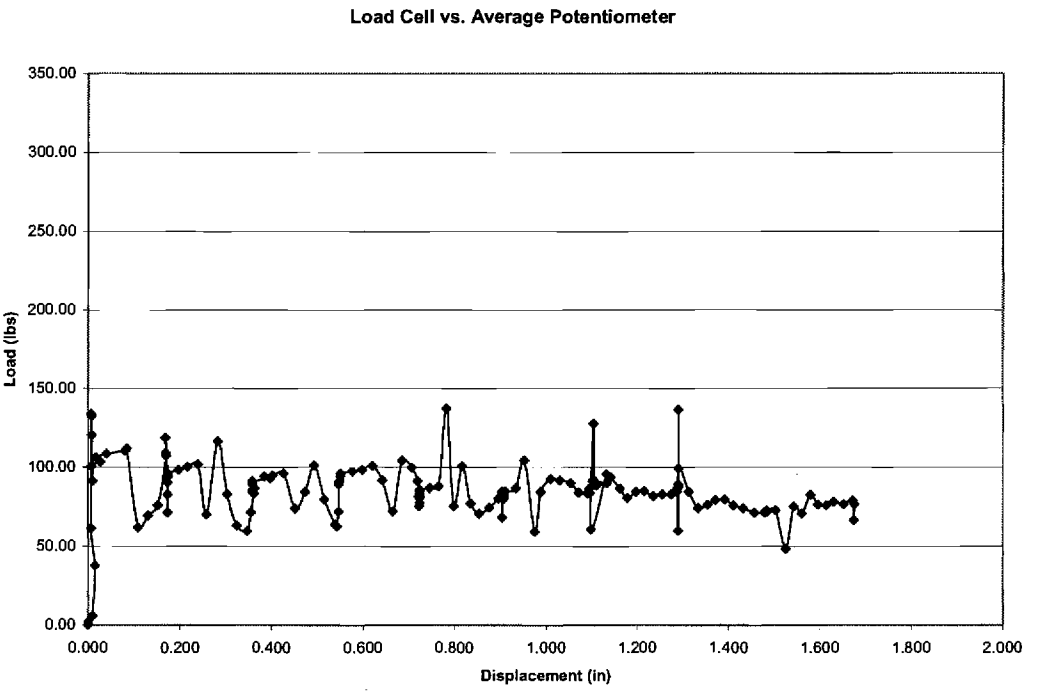


Figure 4.35 Load vs. average potentiometer for steel plate test 3

4.7 Steel Plate and Oil

This test used the steel embedded plate block again with the addition of a sliding surface covered in motor oil. The maximum horizontal force required to move the concrete block was used to calculate the μ_s values for each of the three tests. The values of maximum force and μ_s were 118.58 lbs. and 0.198, 124.44 lbs. and 0.208, and 126.10 lbs. and 0.211 for tests 1, 2, and 3, respectively. The average μ_s value was 0.206. A summary table of maximum horizontal force, μ_s values for each test, and an average μ_s value for the end treatment is presented in Table 4.1 in Section 4.8. Graphs for load vs. LVDT and load vs. average potentiometer for each of the three tests are shown in Figures 4.36 through 4.41.

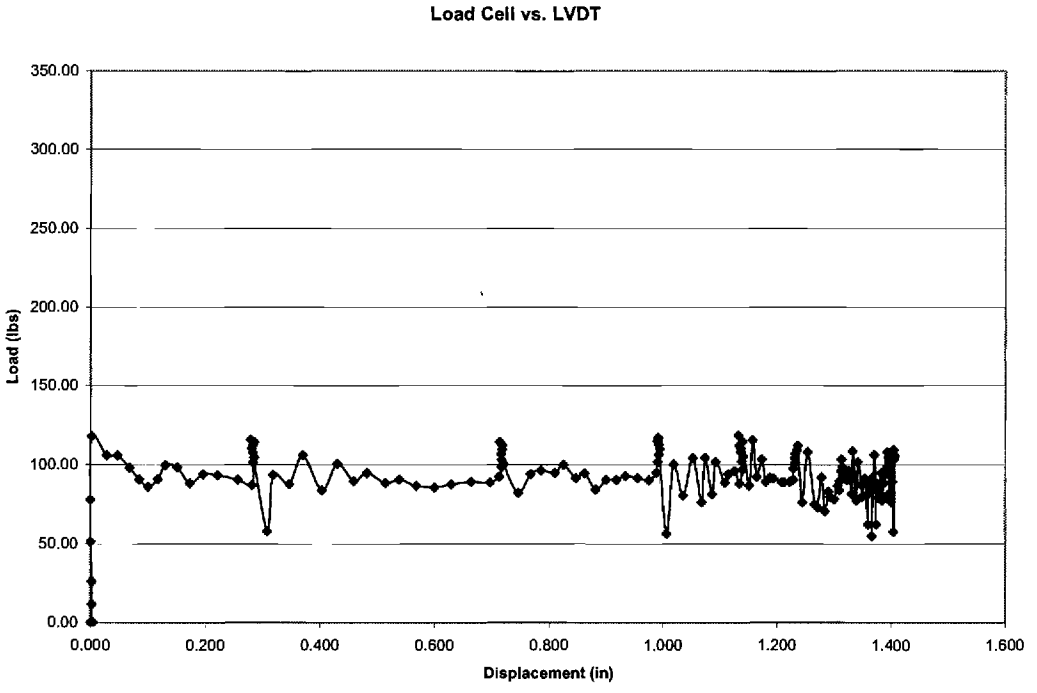


Figure 4.36 Load vs. LVDT for steel plate and oil test 1

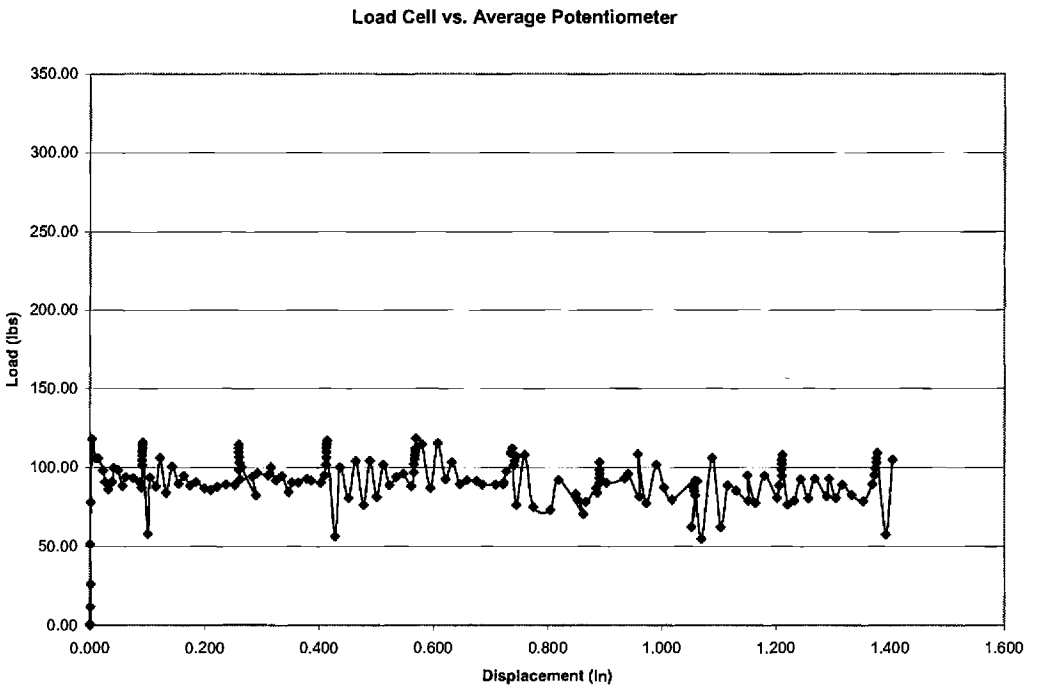


Figure 4.37 Load vs. average potentiometer for steel plate and oil test 1

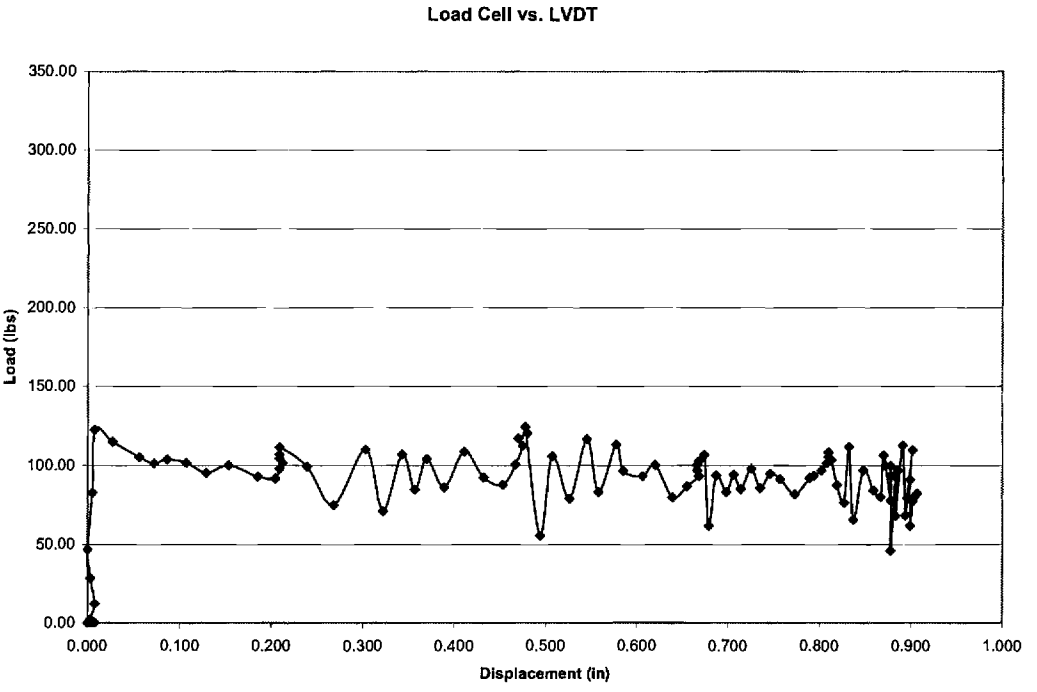


Figure 4.38 Load vs. LVDT for steel plate and oil test 2

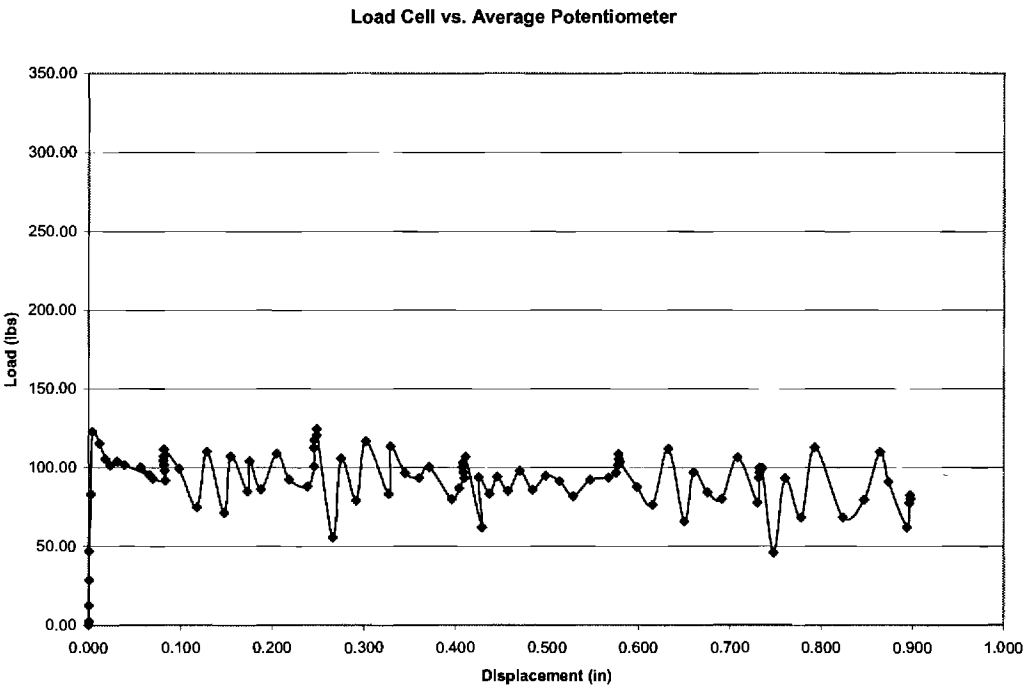


Figure 4.39 Load vs. average potentiometer for steel plate and oil test 2

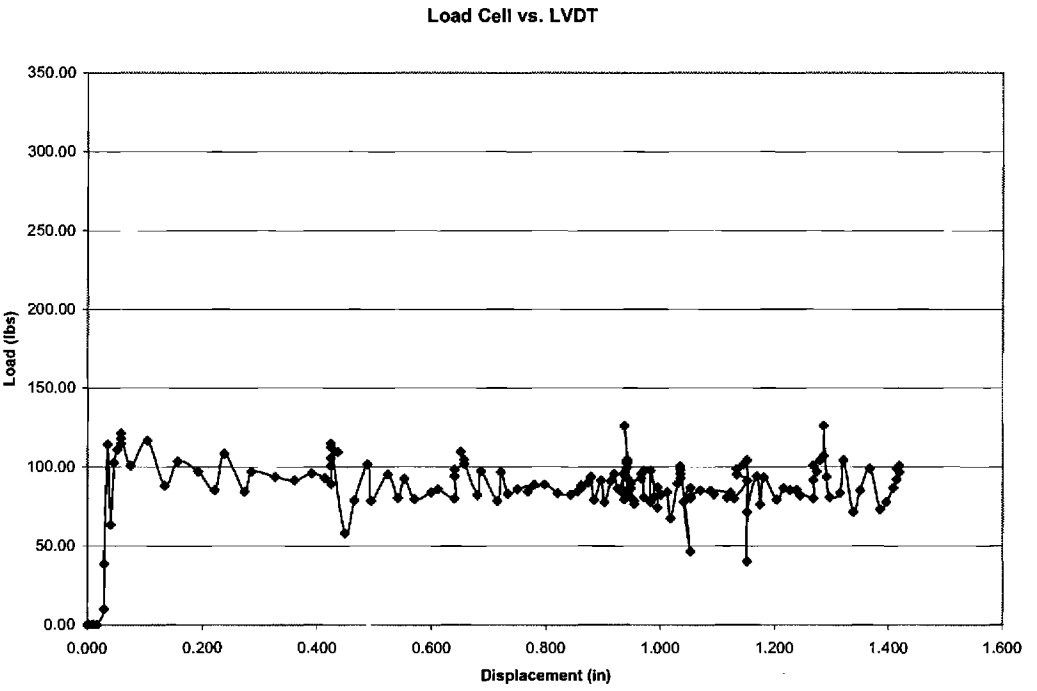


Figure 4.40 Load vs. LVDT for steel plate and oil test 3

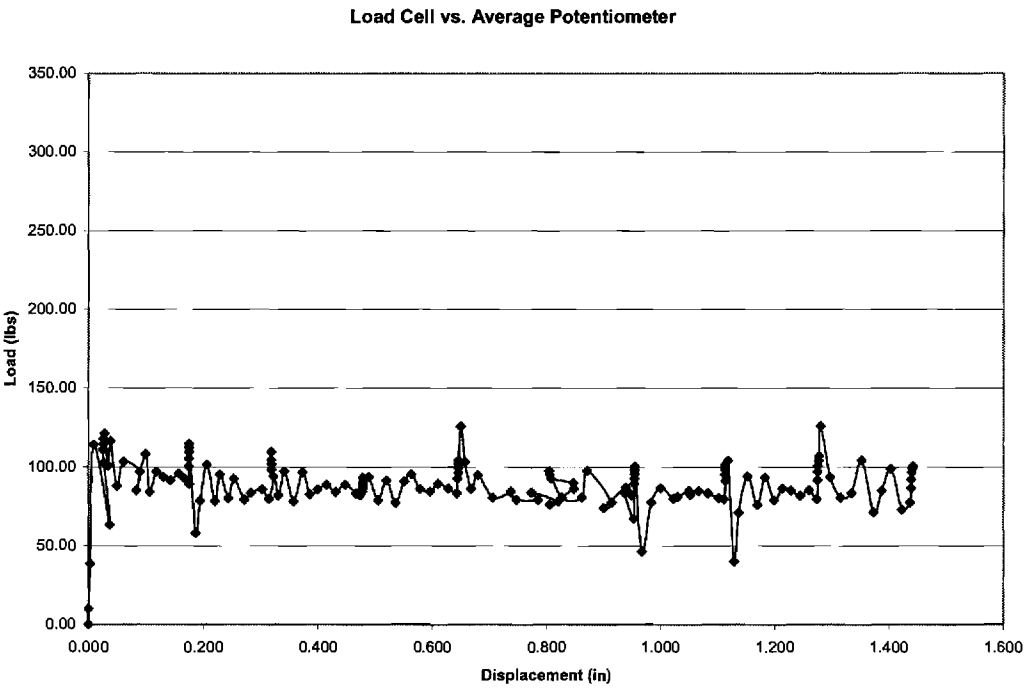


Figure 4.41 Load vs. average potentiometer for steel plate and oil test 3

4.8 Discussion of Laboratory Experiments

Table 4.1 Summary of laboratory experiment results

		Test 1	Test 2	Test 3	Coefficient of Variation	μ_{ave}	$\mu_{ave}/\mu_{control}$ (%)
Control	N (lbs)	563	563	563	10.9%	0.514	100%
	F_{max} (lbs)	268.55	273.81	325.74			
	μ	0.477	0.486	0.579			
Oil Lubricant	N (lbs)	563	563	563	12.4%	0.445	87%
	F_{max} (lbs)	261.06	215.76	275.56			
	μ	0.464	0.383	0.489			
Teflon Pad	N (lbs)	563	563	563	23.7%	0.265	52%
	F_{max} (lbs)	174.21	108.71	164.19			
	μ	0.309	0.193	0.292			
Wax Lubricant	N (lbs)	563	563	563	5.6%	0.232	45%
	F_{max} (lbs)	127.02	139.01	125.68			
	μ	0.226	0.247	0.223			
Steel Plate	N (lbs)	598.5	598.5	598.5	2.2%	0.225	44%
	F_{max} (lbs)	131.61	135.43	137.41			
	μ	0.220	0.230	0.226			
Steel Plate and Oil	N (lbs)	598.5	598.5	598.5	3.2%	0.206	40%
	F_{max} (lbs)	118.58	124.44	126.10			
	μ	0.198	0.208	0.211			

Table 4.1 shows a summary of the six different types of friction reducing techniques tested to reduce the friction at the bearing ends of prestressed concrete bridge girders. Three separate tests were performed and the coefficient of static friction is listed from each individual test along with the average coefficient of static friction of the three tests for each technique. The control specimen required the highest horizontal force to initiate movement while the embedded steel plate with oil coated surface required the lowest horizontal force to initiate movement. The addition of a surface coated in motor oil reduced the friction between the two surfaces by approximately 13.4%. This number was determined by taking the difference between average μ_s values of the control and oil lubricant tests, dividing by the control test and multiplying by 100 as shown:

$X = ((0.514 - 0.445)/0.514)*100$

$X = 13.4\%$

The coefficient of variation (C_v) is a dimensionless number which gives a comparison of the variation of populations that have different values. C_v was calculated by taking the ratio of the standard deviation to the mean and multiplied by 100 to give the number in a percentage. The closer the number is to 0 the less variable the data was. C_v was calculated by Equation (4)[9]:

$$C_v = sd/X \qquad \text{Equation (4)}$$

Where: sd = standard deviation

$X = \mu_{ave}$ from the three tests performed

The standard deviation measures the variability of values to the mean. The higher the range of scores is around the mean, the greater the standard deviation is. The standard deviation was calculated by Equation (5)[9]:

$$sd = \sqrt{(x-X)^2/(N-1))} \qquad \text{Equation (5)}$$

Where: x = the μ_{ave} for each individual test for each friction reducing technique

$X = \mu_{ave}$ from the three tests performed

N = 3 (Number of tests performed)

The $\mu_{ave}/\mu_{control}$ value was found by dividing the μ_{ave} value for a specific test, dividing by the μ_{ave} for the control test and multiplying by 100.

Results for the first steel plate test may have been slightly altered by a few sources of error. The steel plate test was performed once before the motor oil was applied to the steel sliding surface, only to find out that there was some concrete which protruded through the sides of the forms, going underneath the steel plate. The steel plate block was run a second time after the motor oil was spread on the surface. The steel sliding surface was cleaned thoroughly with an acetone cleaner, but remnants of the motor oil may have affected the results slightly. Also, due to the fact that the National Instruments Labview data acquisition system produced output that was very sporadic and variable may have caused slight ambiguities in the final results.

4.9 Conclusion from Laboratory Experiments

After examining the analysis from the laboratory experiments, the most effective method to reduce the friction at the bearing end of prestressed concrete bridge girders is to use the steel plate end treatment with the steel casting beds coated in oil. The teflon pad produced a low value for the coefficient of static friction; μ_s for the teflon pad was 52% of the control test. However, the steel plate with oil coated steel surface's results were very consistent as noted by its low coefficient of variation and yielded the lowest coefficient of friction between the sliding surface of the concrete block and steel bed.

CHAPTER V

FIELD TEST PROCEDURE

5.1 Introduction

Field tests were conducted at Standard Concrete Products plant in Atlanta, GA. Tests were conducted on 12 individual prestressed concrete bridge girders which were being cast for Bridge 4 of the GA-316 over I-85 interchange located in Gwinnett County, Georgia. There were three beams poured at a time on the casting beds at the plant. The five friction reducing techniques used for the girders were: oil coated steel bed, teflon pad, wax lubricant, steel plate, and steel angle. Details of the embedded steel plate are given in Figures 3.5 and 3.6 and details of the steel angle are given in Figure 6.17.

5.2 Field Test Procedure

Measurements for strain, camber, girder sweep, and girder slide were taken for each of the 12 girders. Strain was measured by epoxy bonding two ¼ in. diameter steel stubs with a hole in the center for measuring the change in length after the prestressing strands were cut. One steel stub was bonded on the bottom flange of the concrete approximately 1 in. from the end of the girder and approximately at the center of gravity of the prestressing strands 4 ½ in. above the bottom of the girder using a five minute epoxy adhesive. The second steel stub was spaced 10 in. from the first by using an aluminum bar with two 2-56 x ¾ in. long machine screws protruding through the bar, spaced at approximately 10 inches. Figure 5.1 shows the steel stubs being bonded to the girders in the field.

Figure 5.1 Epoxy bonding steel stubs to bridge girders

A straight vertical line was also drawn on the bottom flange of the concrete girders and continued to the outside face of the steel casting beds to measure any sliding movement made by the ends of the girders after the prestressing strands were cut. This was also done to observe if the girders jumped on the casting beds after the prestressing strands were cut. Figure 5.2 shows the vertical line being drawn.

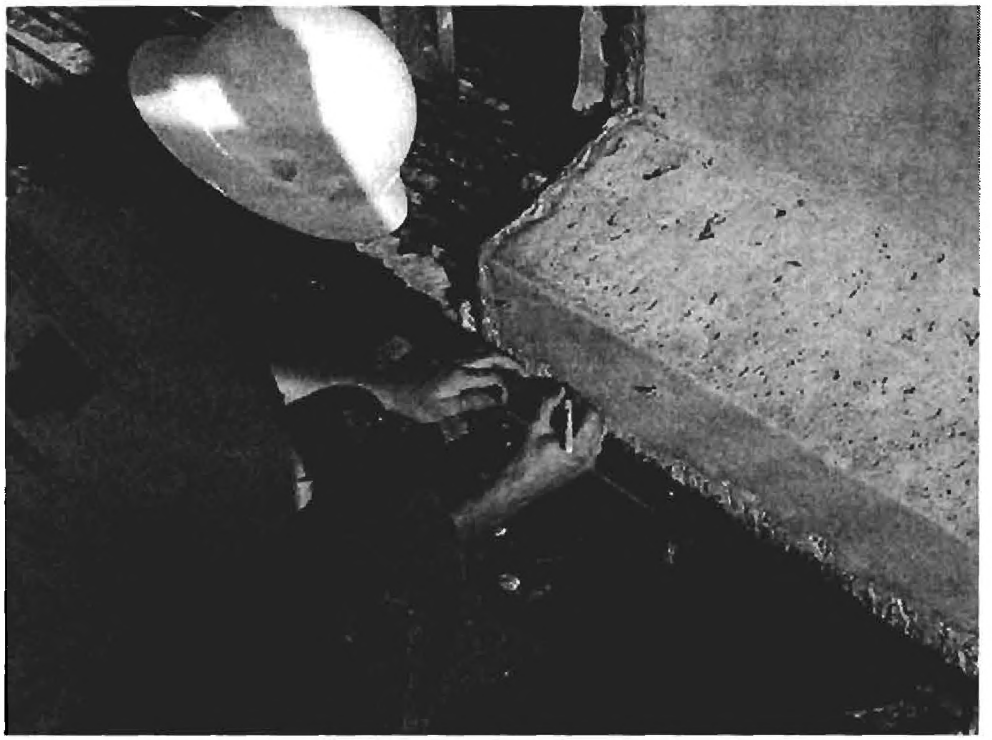


Figure 5.2 Drawing vertical line on girder and casting bed

The last procedure performed on the concrete girders was measuring camber and girder sweep at the midpoint. This was done using a TOPCON GTS-213 Electronic Total Station. Surveying tacks were placed on the top surface of the concrete immediately after it was placed. One tack was placed 8 in. from each end of each girder, which was directly above the center of bearing. The third tack was placed at the midpoint of each girder. Figure 5.3 shows a typical surveying tack placed at 8 in. from the end of the girder.

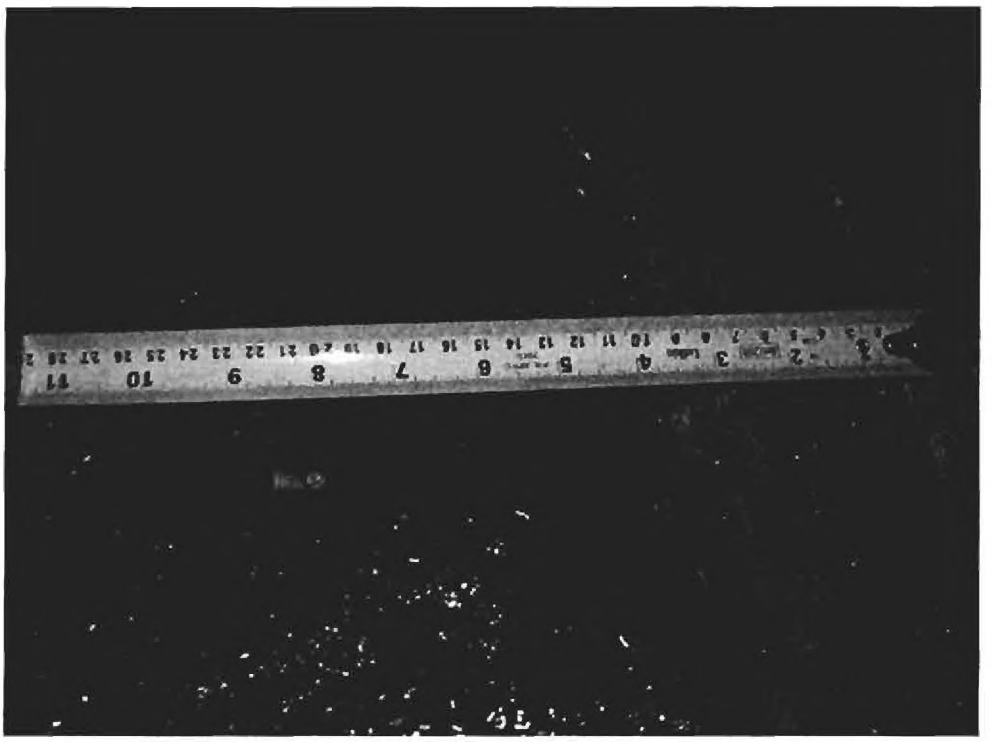


Figure 5.3 Typical surveying tack 8 in. from the girder end

A detachable mechanical (DEMEC) strain gauge was used to measure the change in length between the steel stubs. An initial measurement was taken before the prestressing strands were cut, after the prestressing strands were cut, and after the girders were moved off the casting bed. The DEMEC gauge was accurate to 0.0001 in. By taking measurements before and after the prestressing strands were cut, the change in length was known. A final DEMEC gauge reading was taken after the girders were moved off the casting bed. If more strain was induced after the girders were moved off the casting bed, then there was frictional restraint between the ends of the concrete girders and the casting bed. In theory, if there was no frictional restraint between the ends of the girder and the casting bed, the strain after the prestressing strands were cut and after the girders were moved off the casting bed would be equal. By observing the additional strain induced in the concrete girders, a qualitative amount of frictional restraint was

noted for each of the five friction reducing techniques. Figure 5.4 shows the digital DEMEC strain gauge measuring the distance of the steel stubs.

Figure 5.4 DEMEC strain gauge

Total station measurements were taken at the three aforementioned locations of the concrete girders at three different times: before the prestressing strands were cut, after the prestressing strands were cut, and after the girders were moved off the casting bed. The total station instrument was zeroed at an arbitrary fixed point. A prism rod was held at each of the three locations from which horizontal angle (HR), horizontal distance (HD), and elevation (Z) were taken at the three aforementioned times with respect to that arbitrary fixed point.

The camber of each girder was found after the strands were cut and after the girders were moved off of the casting bed. Camber after the prestressing strands were cut (Δ_{bed}) was calculated by taking the change in elevation (Z) after the prestressing strands were cut less the

elevation before the prestressing strands were cut. Camber after the girders were moved off the casting bed (Δ_{move}) was found by using the elevation of the end points. If the girders were perfectly flat, the elevation of the midpoint would be the average value of the difference in elevation of the two ends. For instance, if the elevation of the east end was eight feet and the elevation of the west end was six feet, the elevation of the midpoint would be seven feet if the girder had no camber. Knowing the elevation of the midpoint if the girder had no camber, that elevation was subtracted from the elevation found from the total station, which was the camber of the girder after it was moved off the casting bed. If there was no frictional restraint between the ends of the girder and the casting bed, there would be no additional camber in the girders when the girders were moved off the casting bed. Figure 5.5 shows the prism rod being held on the top flange and Figure 5.6 shows the total station set-up at the precast concrete plant.

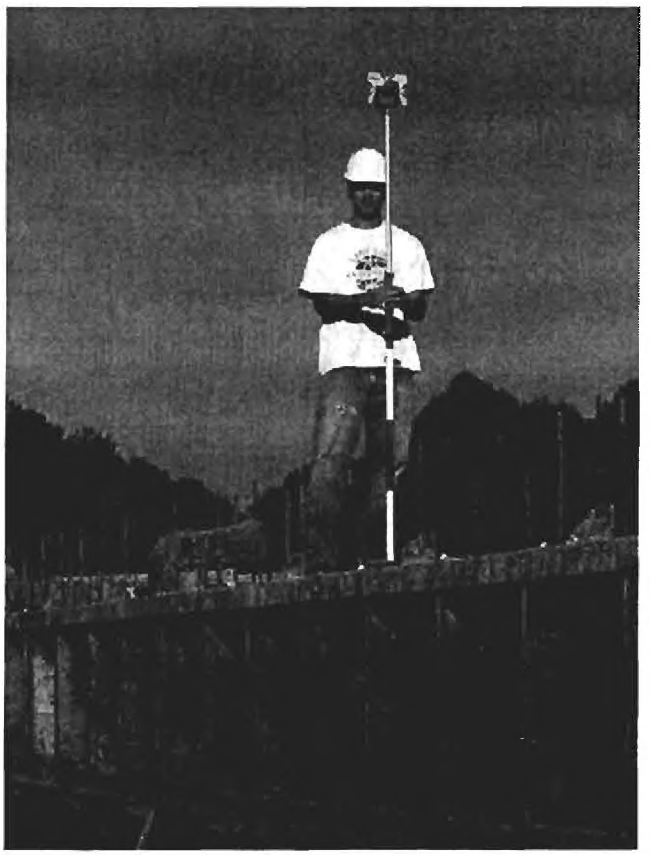


Figure 5.5 Prism rod held on top flange of girder

Figure 5.6 Total station set-up

5.3 Plant Layout and Sign Convention

All 12 girders were poured on beds 5 and 6, with the first three girders poured on bed 6 and the last nine girders poured on bed 5. Figure 5.7 shows a plan view of the girder beds at the precast concrete plant.

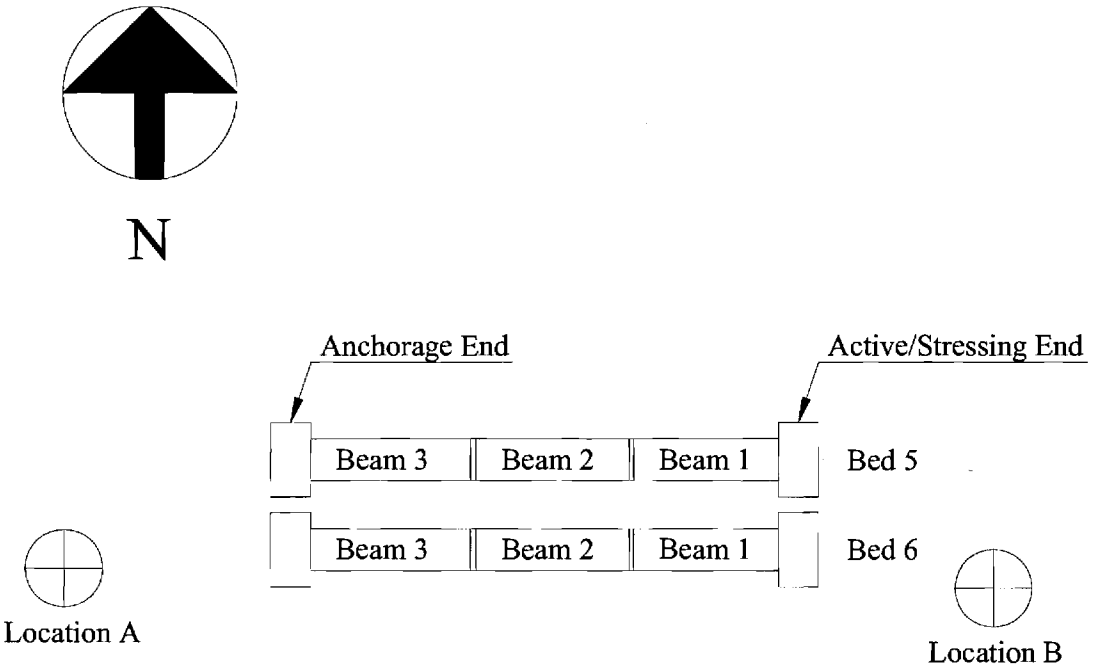


Figure 5.7 Plan view of Standard Concrete Products plant girder beds

Three beams were able to be poured on the beds. Each of the three beams were given a name of either beam 1, beam 2, or beam 3. Location A was the point at which the first three girder total station measurements were taken. Location B was the point at which the last nine girder total station measurements were taken. The east end of the beds was the end where the prestressing strands were tensioned. The west end of the beds was the end where the prestressing strands were anchored. Measurements for strain and girder slide were taken on both the north and south sides of the girders, on both the east and west ends. All strain values were compression strain and were designated a "-" value. Any sliding movement exhibited by the ends of the girders in the west direction was given a "+" value and movement in the east direction was given a "-" value.

5.4 Beam Designation

Each girder was assigned a designation by the Georgia Department of Transportation and by Moreland-Altobelli Associates Inc. The designation was in the form of:

X-Y.Z

where: X was the piece detail of the girder

Y was the bridge span number

Z was the girder number with respect to its span

CHAPTER VI

FIELD TESTS RESULTS AND DISCUSSION

6.1 Introduction

Field tests were conducted at Standard Concrete Products Precast Concrete Plant. Tests were conducted on 12 individual prestressed concrete bridge girders, all which were being cast for Bridge 4 of the GA-316 over I-85 Bridge located in Gwinett County. There were three beams poured at a time on the casting beds at the plant. The five friction reducing techniques used for the girders were: oil coated steel bed, teflon pad, wax lubricant, steel plate, and steel angle. Details for the steel plate are given in Figures 3.5 and 3.6 and details for the steel angle are given in Figure 6.17.

Each girder was assigned an end condition. Each friction reducing technique was used two times, except for the teflon pad which was used four times. Table 6.1 provides information for each girder from provided field data. The "None" technique means an oil-coated steel surface.

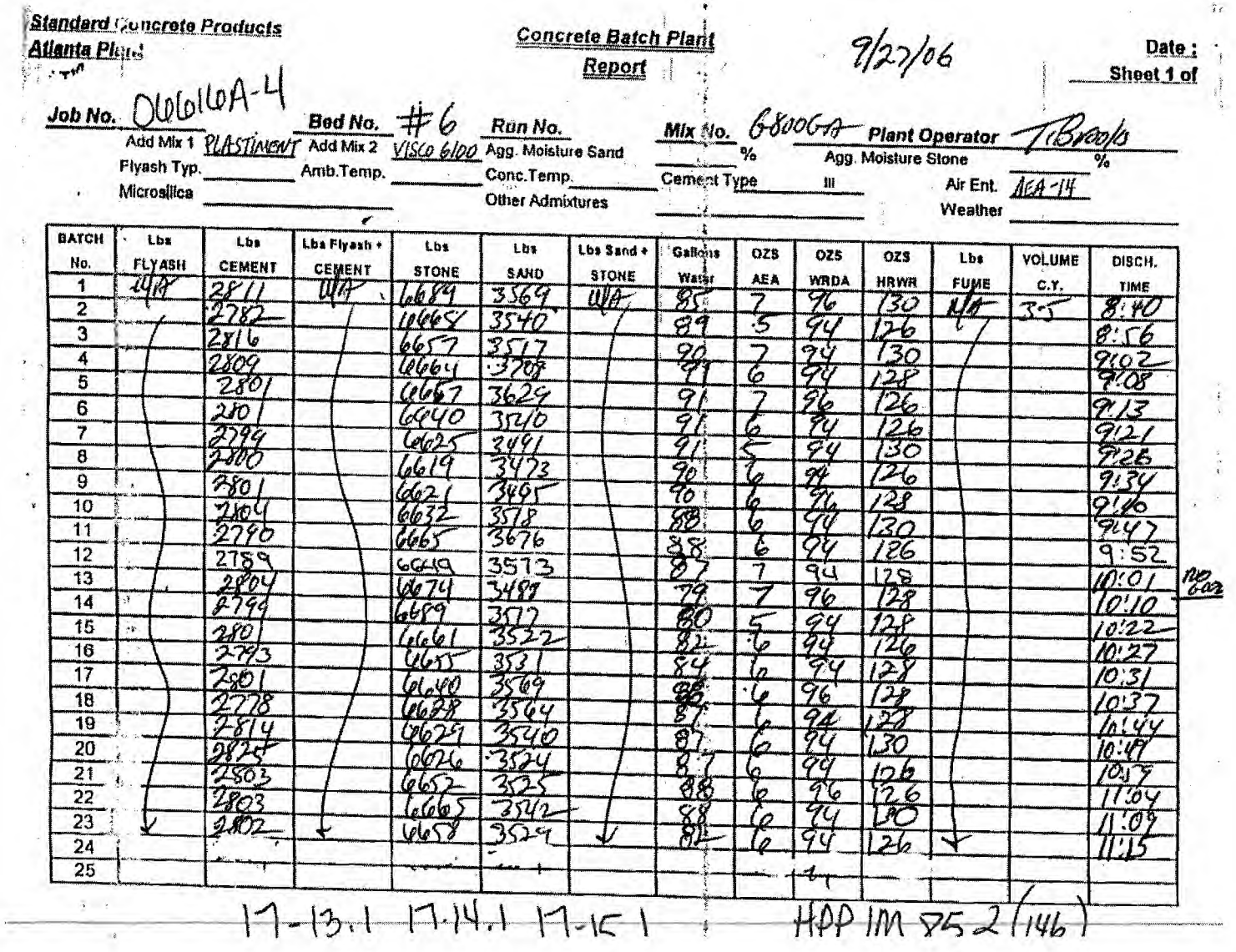
Table 6.1 Beam field information

Beam Designation	Date Cast	Beam on Bed	Length	Weight (kip)	Horizontal Force (kip)	Friction Reducing Technique	Reference Name
17-13.1	9/27/06	1	122'-7 7/8"	97.01	1438.80	Teflon Pad	Pad1
17-14.1	9/27/06	2	122'-8"	96.75	1438.80	Teflon Pad	Pad2
17-15.1	9/27/06	3	122'-8 1/4"	95.77	1438.80	Teflon Pad	Pad3
17-16.1	9/30/06	1	122'-8 1/4"	95.39	1460.70	Wax	Wax1
17-10.5	9/30/06	2	124'-9 3/4"	97.01	1460.70	Wax	Wax2
17-11.5	9/30/06	3	124'-9 3/4"	97.01	1460.70	None	None1
19-19.5	10/3/06	1	124'-4 1/4"	96.75	1355.70	Steel Angle	Angle1
19-20.1	10/3/06	2	124'-4 1/8"	96.75	1355.70	None	None2
19-20.2	10/3/06	3	124'-4 1/8"	96.75	1355.70	Steel Plate	Plate1
19-20.3	10/6/06	1	124'-4 1/8"	98.09	1357.50	Steel Plate	Plate2
19-20.4	10/6/06	2	124'-4 1/8"	98.09	1357.50	Teflon Pad	Pad4
19-20.5	10/6/06	3	124'-4 1/8"	98.09	1357.50	Steel Angle	Angle2

The reference name for each girder was the friction reducing technique used and numbered for the amount that technique was used. Girders are referred to that reference name.

The length of each girder was taken as the slope adjusted length from plan sheets provided by Standard Concrete Products. The total horizontal force was the summation of tension forces placed on the strands and was calculated from field data sheets given in Appendix D.

The weight was calculated by taking the average batch weight in the mix design used for each girder and multiplying by the volume for that specific girder. The volume was provided by Standard Concrete Products. The average batch weight per cubic yard was found by taking the summation of cement, stone, sand, water, and admixtures in the mix design for each batch mix, dividing by the volume of 3 ½ cubic yards, the constant volume per batch, and dividing by the number of batches used. Tables for the weight summation of each mix design and girder weights are found in Appendix I. The conversion of gallons of water to lbs of water was 8.342. The conversion of ounces of admixtures to lbs was 0.0652. The density of admixtures was assumed to be the same as water, 62.4 lbs/ft^3. The mix design field sheets used for the 12 girders are given in Figures 6.1 through 6.4.



Standard Concrete Products
Atlanta Plant

Concrete Batch Plant Report

9/27/06

Date :
Sheet 1 of

Job No. 060616A-4 **Bed No.** #6 **Run No.** **Mix No.** 6800GA **Plant Operator** T. Brooks

Add Mix 1 PLASTIMENT Add Mix 2 VISCO 6100 Agg. Moisture Sand % Agg. Moisture Stone %

Flyash Typ. Amb.Temp. Conc.Temp. Cement Type III Air Ent. AEA-14

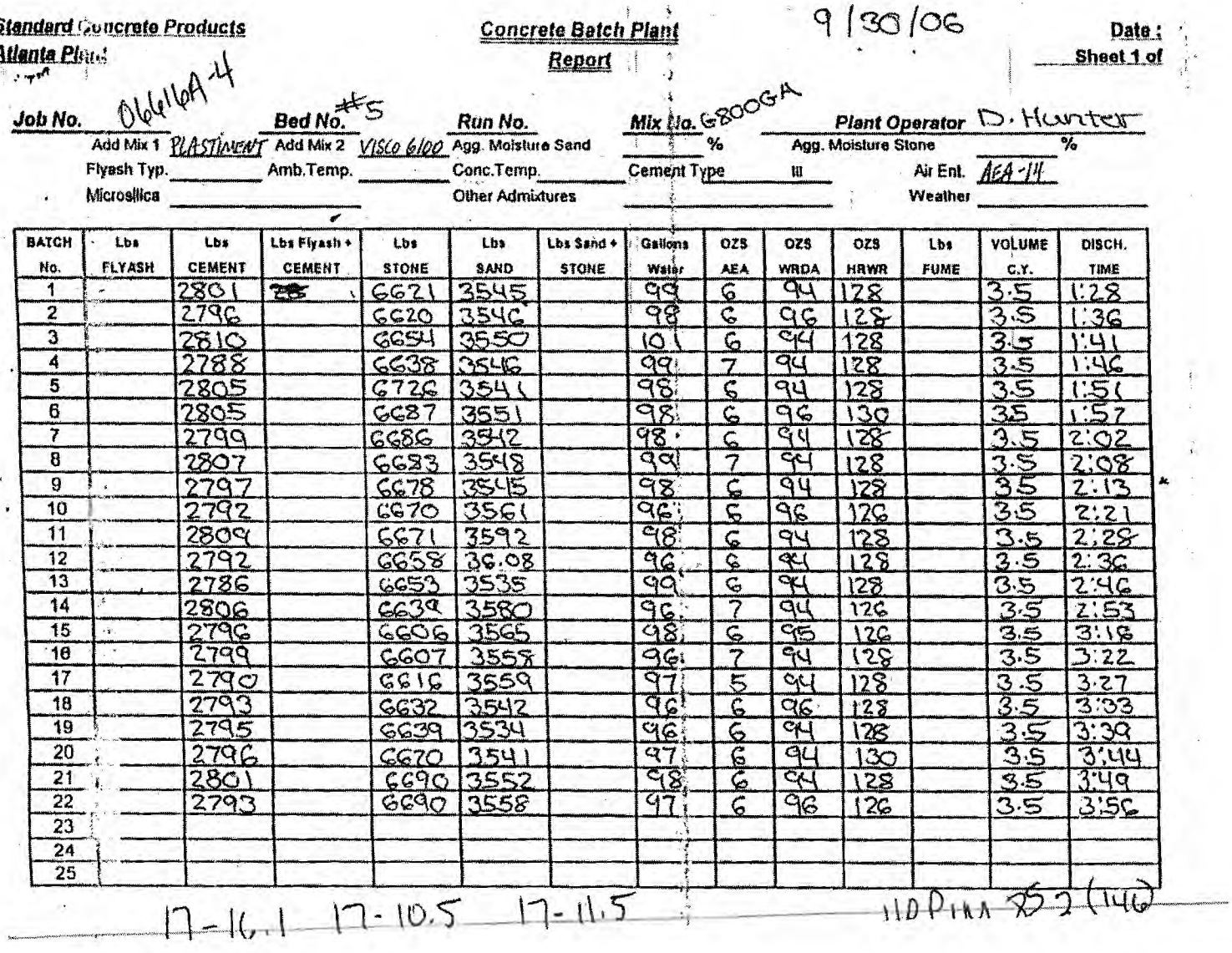
Microsilica Other Admixtures Weather

BATCH No.	Lbs FLYASH	Lbs CEMENT	Lbs Flyash + CEMENT	Lbs STONE	Lbs SAND	Lbs Sand + STONE	Gallons Water	OZS AEA	OZS WRDA	OZS HRWR	Lbs FUME	VOLUME C.Y.	DISCH. TIME
1	N/A	2811	N/A	6689	3569	N/A	85	7	96	130	N/A	3.5	8:40
2		2782		10665	3540		89	5	94	126			8:56
3		2816		6657	3517		90	7	94	130			9:02
4		2809		6664	3708		91	6	94	128			9:08
5		2801		6667	3624		91	7	96	126			9:13
6		280		6640	3540		91	6	94	126			9:21
7		2794		6625	3491		91	5	94	130			9:28
8		2800		6619	3473		90	6	94	126			9:34
9		2801		6621	3495		90	6	94	128			9:40
10		2804		6632	3518		88	6	94	130			9:47
11		2790		6665	3676		88	6	94	126			9:52
12		2789		6649	3573		87	7	94	128			10:01
13		2804		10674	3489		79	7	96	128			10:10
14		2799		6689	3577		80	5	94	128			10:22
15		280		10661	3522		82	6	94	126			10:27
16		2793		6655	3531		84	6	94	128			10:31
17		2801		10640	3569		86	6	96	128			10:37
18		2778		6628	3564		87	6	94	128			10:44
19		2814		10629	3540		87	6	94	130			10:49
20		2825		10626	3524		87	6	94	126			10:57
21		2803		6652	3525		88	6	96	126			11:04
22		2803		10665	3542		88	6	94	130			11:09
23		2802		6658	3529		87	6	94	126			11:15
24													
25													

NO 6002

17-13.1 17-14.1 17-15.1 HPP IM 852 (146)

Figure 6.1 Mix design field sheets pad1, pad2, and pad3



Standard Concrete Products — **Concrete Batch Plant Report** — 9/30/06 — **Date:** — **Sheet 1 of**

Atlanta Plant

Job No. 06616A-4 **Bed No.** #5 **Run No.** **Mix No.** G800GA **Plant Operator** D. Hunter

Add Mix 1 PLASTIMENT Add Mix 2 VISCO 6100 Agg. Moisture Sand % Agg. Moisture Stone %

Flyash Typ. Amb.Temp. Conc.Temp. Cement Type III Air Ent. AEA-14

Microsilica Other Admixtures Weather

BATCH No.	Lbs FLYASH	Lbs CEMENT	Lbs Flyash + CEMENT	Lbs STONE	Lbs SAND	Lbs Sand + STONE	Gallons Water	OZS AEA	OZS WRDA	OZS HRWR	Lbs FUME	VOLUME C.Y.	DISCH. TIME
1		2801	[illegible]	6621	3545		99	6	94	128		3.5	1:28
2		2796		6620	3546		98	6	96	128		3.5	1:36
3		2810		6654	3550		101	6	94	128		3.5	1:41
4		2788		6638	3546		99	7	94	128		3.5	1:46
5		2805		6726	3541		98	6	94	128		3.5	1:51
6		2805		6687	3551		98	6	96	130		3.5	1:57
7		2799		6686	3542		98	6	94	128		3.5	2:02
8		2807		6683	3548		99	7	94	128		3.5	2:08
9		2797		6678	3545		98	6	94	128		3.5	2:13
10		2792		6670	3561		96	6	96	126		3.5	2:21
11		2809		6671	3592		98	6	94	128		3.5	2:28
12		2792		6658	3608		96	6	94	128		3.5	2:36
13		2786		6653	3535		99	6	94	128		3.5	2:46
14		2806		6639	3580		96	7	94	126		3.5	2:53
15		2796		6606	3565		98	6	95	126		3.5	3:18
16		2799		6607	3558		96	7	94	128		3.5	3:22
17		2790		6616	3559		97	5	94	128		3.5	3:27
18		2793		6632	3542		96	6	96	128		3.5	3:33
19		2795		6639	3534		96	6	94	128		3.5	3:39
20		2796		6670	3541		97	6	94	130		3.5	3:44
21		2801		6690	3552		98	6	94	128		3.5	3:49
22		2793		6690	3558		97	6	96	126		3.5	3:56
23													
24													
25													

17-16.1 17-10.5 17-11.5 HDPHA 252 (146)

Figure 6.2 Mix design field sheets wax1, wax2, and none1

Standard Concrete Products Two Loads went To Barriers **Concrete Batch Plant Report** 10/3/06 **Date :**

Atlanta Plant **Sheet 1 of**

Job No. **Bed No.** #5 **Run No.** **Mix No.** G752GA **Plant Operator** D. Hunter

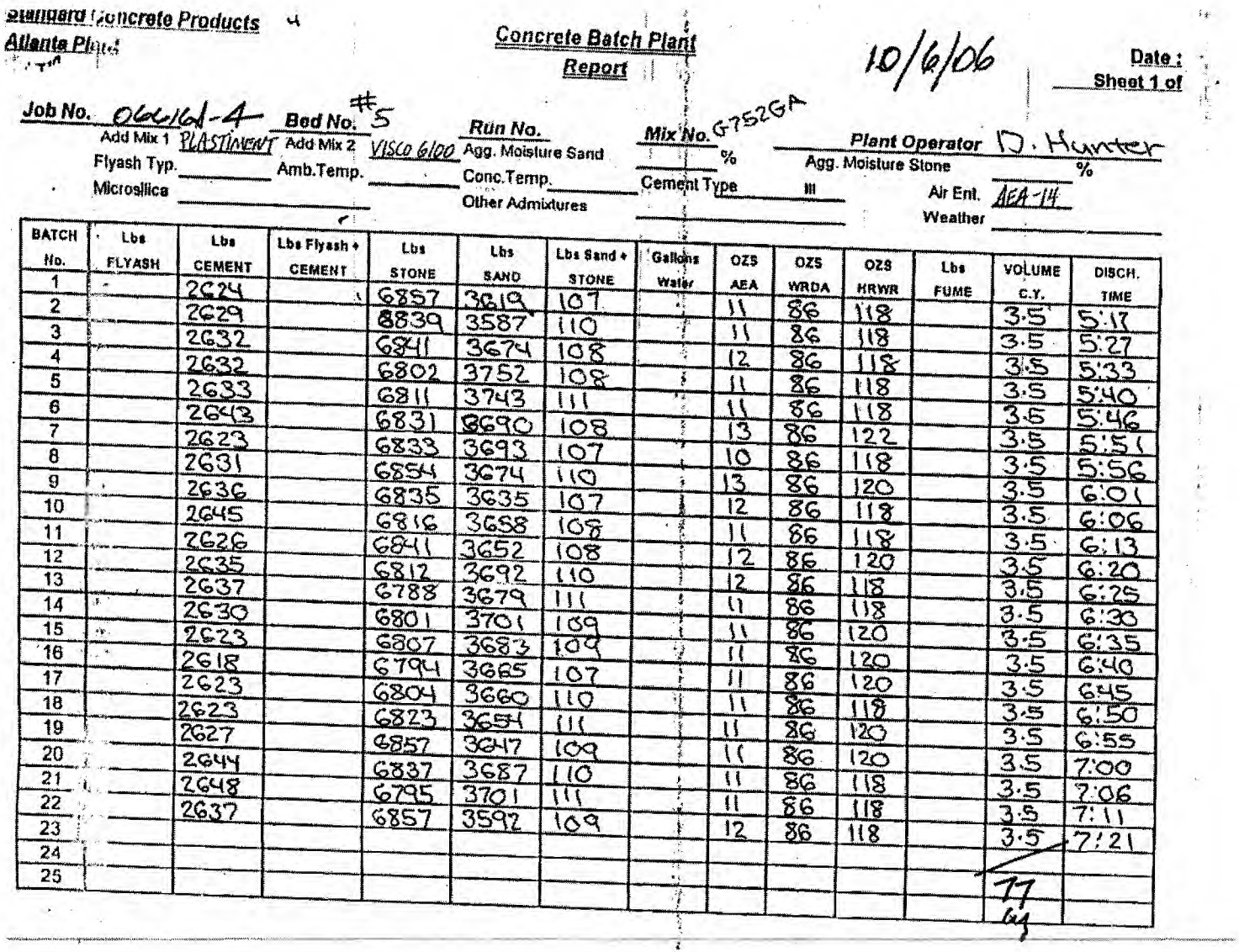
Add Mix 1 PLASTIMENT Add Mix 2 VISCO 6100 Agg. Moisture Sand % Agg. Moisture Stone %

Flyash Typ. Amb.Temp. Conc.Temp. Cement Type III Air Ent. AEA-14

Microsilica Other Admixtures Weather

BATCH No.	Lbs FLYASH	Lbs CEMENT	Lbs Flyash + CEMENT	Lbs STONE	Lbs SAND	Lbs Sand + STONE	Gallons Water	OZS AEA	OZS WRDA	OZS HRWR	Lbs FUME	VOLUME C.Y.	DISCH. TIME
1	Barrier	2630		6813	3628		96	11	86	118		3.5	4:19 Bed
2		2641		6816	3629		88	11	86	120		3.5	4:28
3		2636		6836	3636		87	12	86	120		3.5	4:40
4		2628		6818	3633		89	11	86	120		3.5	4:45
5		2635		6835	3635		88	12	86	118		3.5	4:50
6		2624		6841	3594		89	12	86	120		3.5	4:55
7		2636		6845	3623		89	12	86	118		3.5	5:00
8		2633		6820	3601		88	11	86	118		3.5	5:05
9		2630		6817	3626		89	11	86	118		3.5	5:10
10		2627		6799	3615		87	11	86	120		3.5	5:15
11		2629		6805	3617		86	11	86	118		3.5	5:20
12		2625		6799	3620		87	11	86	118		3.5	5:25
13		2637		6825	3616		89	11	86	118		3.5	5:30
14		2628		6847	3642		88	11	86	122		3.5	5:35
15		2634		6845	3658		88	11	86	120		3.5	5:40
16		2631		6814	3657		89	12	86	118		3.5	5:45
17		2621		6829	3648		87	11	86	118		3.5	5:50
18		2636		6865	3645		86	11	86	118		3.5	5:55
19		2631		6863	3641		88	12	86	118		3.5	6:00
20	Barrier	2651		6858	3660		89	11	84	122		3.5	6:19
21		2708		6843	3650		86	11	86	118		3.5	6:37
22		2668		6839	3625		88	13	86	118		3.5	6:42
23		2655		6842	3632		87	11	86	120		3.5	6:47
24		2654		6809	3621		86	11	86	118		3.5	6:52
25													

Figure 6.3 Mix design field sheets angle1, none2, and plate1



Standard Concrete Products
Atlanta Plant

Concrete Batch Plant Report

10/6/06

Date :
Sheet 1 of

Job No. 06616-4 Bed No. #5 Run No. Mix No. G752GA

Add Mix 1 PLASTIMENT Add Mix 2 VISCO 6100 Agg. Moisture Sand % Plant Operator D. Hunter

Flyash Typ. Amb.Temp. Conc.Temp. Cement Type III Agg. Moisture Stone %

Microsilica Other Admixtures Air Ent. AEA-14

Weather

BATCH No.	Lbs FLYASH	Lbs CEMENT	Lbs Flyash + CEMENT	Lbs STONE	Lbs SAND	Lbs Sand + STONE	Gallons Water	OZS AEA	OZS WRDA	OZS HRWR	Lbs FUME	VOLUME C.Y.	DISCH. TIME
1		2624		6857	3619	107		11	86	118		3.5	5:17
2		2629		6839	3587	110		11	86	118		3.5	5:27
3		2632		6841	3674	108		12	86	118		3.5	5:33
4		2632		6802	3752	108		11	86	118		3.5	5:40
5		2633		6811	3743	111		11	86	118		3.5	5:46
6		2643		6831	3690	108		13	86	122		3.5	5:51
7		2623		6833	3693	107		10	86	118		3.5	5:56
8		2631		6854	3674	110		13	86	120		3.5	6:01
9		2636		6835	3635	107		12	86	118		3.5	6:06
10		2645		6816	3658	108		11	86	118		3.5	6:13
11		2626		6841	3652	108		12	86	120		3.5	6:20
12		2635		6812	3692	110		12	86	118		3.5	6:25
13		2637		6788	3679	111		11	86	118		3.5	6:30
14		2630		6801	3701	109		11	86	120		3.5	6:35
15		2623		6807	3683	109		11	86	120		3.5	6:40
16		2618		6794	3665	107		11	86	120		3.5	6:45
17		2623		6804	3660	110		11	86	118		3.5	6:50
18		2623		6823	3654	111		11	86	120		3.5	6:55
19		2627		6857	3647	109		11	86	120		3.5	7:00
20		2644		6837	3687	110		11	86	118		3.5	7:06
21		2648		6795	3701	111		11	86	118		3.5	7:11
22		2637		6857	3592	109		12	86	118		3.5	7:21
23													
24												77	
25												cy	

Figure 6.4 Mix design field sheets plate2, pad4, and angle2

6.2 None1 and None2

None1 and none2 were girders that used no specific friction reducing technique but had the steel casting surface coated in oil. Field information for DEMEC readings, total station readings, strand tensioning, and concrete properties for none1 and none2 are found in Appendices B through E, respectively. Table 6.2 shows the field information for none1 and none2. The length was taken as the in-plane length from plan sheets provided by Standard Concrete Products.

Table 6.2 Beam field information for none1 and none2

Beam Designation	Date Cast	Beam on Bed	Length	Weight (kip)	Horizontal Force (kip)	Friction Reducing Technique	Reference Name
17-11.5	9/30/06	3	124'-9 3/4"	97.01	1460.70	oil	None1
19-20.1	10/3/06	2	124'-4 1/8"	96.75	1355.70	oil	None2

Girders none1 and none2 exhibited large frictional tensile cracks typically 1/16 in. wide and shearing off the bottom corner of the girder on which the girder rested. None2 exhibited frictional tensile cracks extending above the bottom flange to the sloped portion of the bottom flange. These cracks existed at the West end of the girder, on both the North and South sides. Figures 6.5, 6.6, and 6.7 show cracks that developed using only oil on the steel bed.

Figure 6.5 Cracked northeast corner of none1

Figure 6.6 Cracked northwest corner of none2

Figure 6.7 Crack on top of bulb on southwest corner of none2

Table 6.3 shows the average strain values at both ends of the girders after the prestressing strands were cut (ε_{bed}) and after the girders were removed off the casting bed (ε_{move}).

Table 6.3 Average strain values for none1 and none2

Ref. Name	Beam	End	Side	ε_{bed}	ε_{move}	Avg. ε_{bed}	Avg. ε_{move}	$\varepsilon_{bed}/\varepsilon_{move}$	% ε_{added}
None1	17-11.5	East	North	-0.00046	-0.00059	-0.00040	-0.00056	71%	40%
		East	South	-0.00034	-0.00053	-	-	-	-
		West	North	-0.00024	-0.00036	-0.00024	-0.00085	28%	262%
		West	South	-0.00023	-0.00134	-	-	-	-
None2	19-20.1	East	North	-0.00044	-0.00077	-0.00044	-0.00075	59%	70%
		East	South	-0.00044	-0.00073	-	-	-	-
		West	North	-0.00054	-0.00104	-0.00046	-0.00087	53%	89%
		West	South	-0.00038	-0.00070	-	-	-	-

Average strain values for both ε_{bed} and ε_{move} were found by averaging the strains calculated on the same end of the girder. For instance, the average ε_{bed} for the east end used ε_{bed}

for the northeast and southeast sides. Also listed is the difference in additional strain induced into the girder after the girders were removed from the casting bed ($\%\ \varepsilon_{added}$). The more additional strain induced after the girders were removed from the casting bed shows there was more frictional restraint with the ends of the girders and the casting bed, less additional strain shows there was less frictional restraint. This percent increase in strain shown in Table 6.3 is the first relationship presented between the friction between the friction reducing technique of the girder and the casting bed. The percent added ε was calculated as follows:

$$\%\ \varepsilon_{added} = \frac{\varepsilon_{bed} - \varepsilon_{move}}{\varepsilon_{bed}} * 100$$

Table 6.4 shows the camber of the girder after the prestressing strands were cut, after the girder was removed from the casting bed, and the change in total length of the girder.

Table 6.4 Camber and length change for none1 and none2

Ref. Name	Beam	ΔL (in)	Δ_{bed} (in)	Δ_{move} (in)	$\Delta_{bed}/\Delta_{move}$ (%)	% Δ_{add} from Move
None1	17-11.5	1.28	1.98	3.27	61%	65%
None2	19-20.1	1.19	2.64	3.12	85%	18%

The length change of each girder was found using field measurements for the distance each end of the girder moved along the bed found in Tables F.2 and F.3 in Appendix F. In some instances both ends moved in the same direction. In that scenario, the girder jumped while on the steel casting bed after the prestressing strands were cut. In other instances both ends have a positive or negative distance for west or east movement, respectively. In that scenario, the girder did not jump. The length change was calculated by adding the absolute values of each end's movement if the ends had different signs and by subtracting the absolute values of each end's movement if the ends had the same sign. An example calculation, with values taken from Table

F.2 in Appendix F for girder none1, is shown when the ends of the girder moved in the same direction as follows:

$$\Delta L = \left| 11/16" \right| + \left| -19/32" \right|$$

$$\Delta L = 1.28"$$

The length change calculation would be the same for a girder with both ends that moved in the same direction except that the two values would be subtracted to find the total length change.

The length change of the girder shown in Table 6.4 is the second relationship presented between the friction between the end condition of the girder and the casting bed.

The percent Δ_{add} was calculated as follows:

$$\% \Delta_{add} = \frac{\Delta_{bed} - \Delta_{move}}{\Delta_{bed}} * 100$$

This percent increase in camber shown in Table 6.4 is the final relationship between the friction between the end condition of the girder and the casting bed.

Table 6.5 shows a quantitative analytical summary of the performance of having no friction reducing technique and Table 6.6 shows the coefficient of variation for those measured values.

Table 6.5 Performance summary for none1 and none2

Ref. Name	Weight (kip)	Hor. Force (kip)	Avg. % ε_{add} from Move	Avg. $\varepsilon_{bed}/\varepsilon_{move}$	ΔL (in)	% Δ_{add} from Move	Avg. $\Delta_{bed}/\Delta_{move}$
None1	97.01	1460.70	151%	50%	1.28	65%	61%
None2	96.75	1355.70	80%	56%	1.19	18%	85%

Table 6.6 Coefficients of variation for none1 and none2

Ref. Name	C_v ε_{bed}	C_v ε_{move}	C_v ΔL	C_v Δ_{bed}	C_v Δ_{move}
None1	34%	62%	5%	20%	3%
None2	15%	19%			

From the information in Table 6.5, having no friction reducing technique, other than oil, exhibited high frictional restraint between the ends of the girder and the casting bed. The additional compressive strain in the girders after the girders were moved off the casting bed ranged from 80% to 151%, and the additional camber induced into the girders after the girders were moved off the casting bed ranged from 18% to 65%. The length change ranged from 1.19 in. to 1.28 in. These values were among the highest of the five different friction reducing techniques.

The ratios of $\varepsilon_{bed}/\varepsilon_{move}$ and $\Delta_{bed}/\Delta_{move}$ ranged from 50% to 56% and 61% to 85%, respectively. A $\varepsilon_{bed}/\varepsilon_{move}$ and $\Delta_{bed}/\Delta_{move}$ ratio equal to 100% means there was no additional strain or camber in the girders after they were moved off the casting bed. In other words, there was no frictional restraint between the steel casting bed and the ends of the girder. Table 6.5 was compiled with the other friction reducing techniques' summaries into Table 6.29, presented in Section 6.8.

From the information in Table 6.6, the coefficients of variation between the measurements taken were moderate. The coefficient of variation for ΔL, Δ_{bed}, and Δ_{move} were found by using the values for both of the girders, which was why there was only one value for the friction reducing technique. The coefficient of variation for ΔL, Δ_{bed}, and Δ_{move} were considerably lower than for ε_{bed} and ε_{move}, typically seen with all the friction reducing techniques.

6.3 Pad1, Pad2, Pad3, and Pad4

Pad1, pad2, pad3, and pad4 were girders that used the teflon pad end condition. Field information for DEMEC readings, total station readings, strand tensioning, and concrete properties for pad1, pad2, pad3, and pad4 are found in Appendices B through E, respectively. Table 6.7 shows the field information for pad1, pad2, pad3, and pad4. The length was taken as the in-plane length from plan sheets provided by Standard Concrete Products.

Table 6.7 Beam field information for pad1, pad2, pad3, and pad4

Beam Designation	Date Cast	Beam on Bed	Length	Weight (kip)	Horizontal Force (kip)	Friction Reducing Technique	Reference Name
17-13.1	9/27/06	1	122'-7 7/8"	97.01	1438.80	Teflon Pad	Pad1
17-14.1	9/27/06	2	122'-8"	96.75	1438.80	Teflon Pad	Pad2
17-15.1	9/27/06	3	122'-8 1/4"	95.77	1438.80	Teflon Pad	Pad3
19-20.4	10/6/06	2	124'-4 1/8"	98.09	1357.50	Teflon Pad	Pad4

The teflon pad used by Standard Concrete Products was placed on both ends of the girder and was approximately 2 in. long from the end of the girder, as shown in Figure 6.6.

Figure 6.8 Teflon pad for pad2 (typical)

Girders pad1, pad2, pad3, and pad4 exhibited large frictional tensile cracks typically 1/16" wide and shearing off the bottom corner of the girder on which the girder rested. Figures 6.9 and 6.10 show typical cracks that were created when the teflon pad was used.

Figure 6.9 Cracked southeast corner of pad2

Figure 6.10 Spalled southeast corner of pad4

Table 6.8 shows the average strain values at both ends of the girders after the prestressing strands were cut (ε_{bed}) and after the girders were removed off the casting bed (ε_{move}).

Table 6.8 Average strain values for pad1, pad2, pad3, and pad4

Ref. Name	Beam	End	Side	ε_{bed}	ε_{move}	Avg. ε_{bed}	Avg. ε_{move}	$\varepsilon_{bed}/\varepsilon_{move}$	% ε_{add} from Move
Pad1	17-13.1	East	North	-0.00024	-0.00065	-0.00033	-0.00078	42%	136%
		East	South	-0.00042	-0.00091	-	-	-	-
		West	North	-0.00033	-0.00072	-0.00035	-0.00061	57%	74%
		West	South	-0.00037	-0.00050	-	-	-	-
Pad2	17-14.1	East	North	-0.00086	-0.00124	-0.00079	-0.00113	70%	43%
		East	South	-0.00071	-0.00101	-	-	-	-
		West	North	-0.00039	-0.00052	-0.00046	-0.00073	63%	59%
		West	South	-0.00052	-0.00093	-	-	-	-
Pad3	17-15.1	East	North	-0.00023	-0.00050	-0.00028	-0.00050	56%	80%
		East	South	-0.00032	-0.00049	-	-	-	-
		West	North	-0.00015	-0.00037	-0.00030	-0.00053	57%	77%
		West	South	-0.00045	-0.00069	-	-	-	-
Pad4	19-20.4	East	North	-0.00038	-0.00080	-0.00048	-0.00091	52%	91%
		East	South	-0.00057	-0.00101	-	-	-	-
		West	North	-0.00049	-0.00087	-0.00058	-0.00098	59%	70%
		West	South	-0.00066	-0.00108	-	-	-	-

Average strain values for both ε_{bed} and ε_{move} were found by averaging the strains calculated on the same end of the girder. For instance, the average ε_{bed} for the east end used ε_{bed} for the northeast and southeast side.

Table 6.9 shows the camber of the girder after the prestressing strands were cut, after the girder was removed from the casting bed, and the change in total length of the girder.

Table 6.9 Camber and length change for pad1, pad2, pad3, and pad4

Ref. Name	Beam	ΔL (in)	Δ_{bed} (in)	Δ_{move} (in)	$\Delta_{bed}/\Delta_{move}$	% Δ_{add} from Move
Pad1	17-13.1	1.53	2.16	3.33	65%	54%
Pad2	17-14.1	1.30	2.34	3.24	72%	38%
Pad3	17-15.1	0.86	2.04	3.15	65%	54%
Pad4	19-20.4	1.22	2.64	3.18	83%	20%

The length change of each girder was found using field measurements for the distance each end of the girder moved along the bed found in Tables F.1 and F.4 in Appendix F.

Table 6.10 shows a qualitative analytical summary of the performance of the teflon pad end condition and Table 6.11 shows the coefficient of variation for those measured values.

Table 6.10 Performance summary for pad1, pad2, pad3 and pad4

Ref. Name	Weight (kip)	Hor. Force (kip)	Avg. % ε_{add} from Move	Avg. $\varepsilon_{bed}/\varepsilon_{move}$	ΔL (in)	% Δ_{add} from Move	Avg. $\Delta_{bed}/\Delta_{move}$
Pad1	97.01	1438.80	105%	50%	1.53	54%	65%
Pad2	96.75	1438.80	51%	66%	1.30	38%	72%
Pad3	95.77	1438.80	78%	56%	0.86	54%	65%
Pad4	98.09	1357.50	80%	56%	1.22	20%	83%

Table 6.11 Coefficients of variation for pad1, pad2, pad3 and pad4

Ref. Name	C_v ε_{bed}	C_v ε_{move}	C_v ΔL	C_v Δ_{bed}	C_v Δ_{move}
Pad1	22%	24%	23%	11%	2%
Pad2	33%	32%			
Pad3	45%	26%			
Pad4	23%	14%			

From the information in Table 6.10, using the teflon pad as the friction reducing technique exhibited high frictional restraint between the ends of the girder and the casting bed. The additional compressive strain in the girders after the girders were moved off the casting bed ranged from 51% to 105% and the additional camber in the girders after the girders were moved off the casting bed ranged from 20% to 54%. The length change ranged from 0.86 in. to 1.53 in.

The ratios of $\varepsilon_{bed}/\varepsilon_{move}$ and $\Delta_{bed}/\Delta_{move}$ ranged from 50% to 66% and 65% to 83%, respectively. A $\varepsilon_{bed}/\varepsilon_{move}$ and $\Delta_{bed}/\Delta_{move}$ ratio equal to 100% means there was no additional strain or camber in the girders after they were moved off the casting bed. In other words, there was no frictional restraint between the steel casting bed and the ends of the girder. Table 6.10 was compiled with the other friction reducing technique's summaries into Table 6.29, presented in Section 6.8.

From the information in Table 6.11, the coefficients of variation between the measurements taken were moderate. The coefficient of variation for ΔL, Δ_{bed}, and Δ_{move} were found by using the values from the four girders, which was why there was only one value for the friction reducing technique.

6.4 Wax1 and Wax2

Wax1 and wax2 were girders that used the wax lubricant. Field information for DEMEC readings, total station readings, strand tensioning, concrete properties, and mix designs for wax1 and wax2 are found in Appendices B through E, respectively. Table 6.12 shows the field information for wax1 and wax2. The length was taken as the in-plane length from plan sheets provided by Standard Concrete Products.

Table 6.12 Beam field information for wax1 and wax2

Beam Designation	Date Cast	Beam on Bed	Length	Weight (kip)	Horizontal Force (kip)	Friction Reducing Technique	Reference Name
17-16.1	9/30/06	1	122'-8 1/4"	95.39	1460.70	Wax	Wax1
17-10.5	9/30/06	2	124'-9 3/4"	97.01	1460.70	Wax	Wax2

The wax lubricant was spread on the casting bed, coating a 16 in. length from the end. Figure 6.11 shows the wax lubricant being applied to the casting bed.

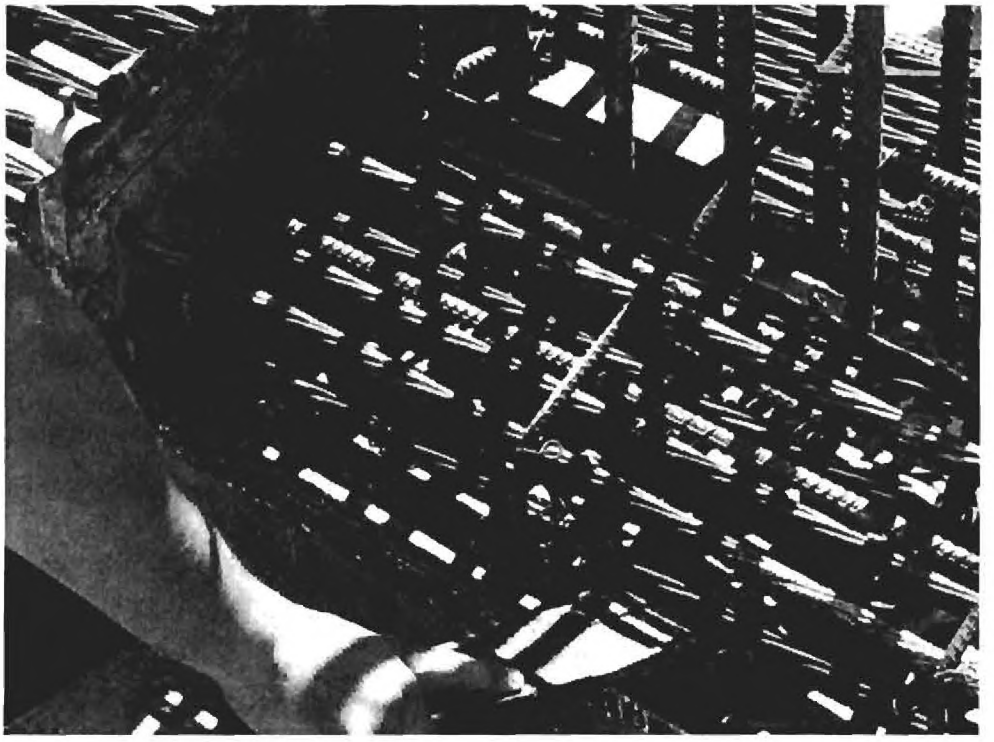


Figure 6.11 Wax lubricant applied to west end of wax1

Wax1 and wax2 exhibited frictional tensile cracks typically 1/16" wide starting from the corner of the girder as shown in Figure 6.12.

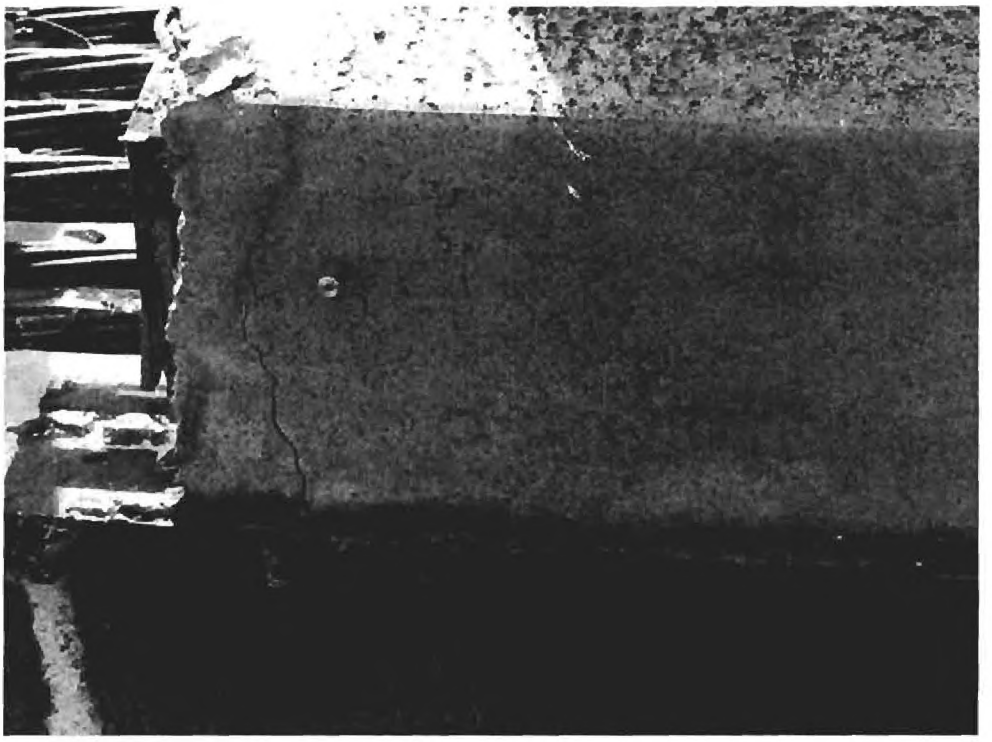


Figure 6.12 Cracked northeast corner of wax1

Table 6.13 shows the average strain values at both ends of the girders after the prestressing strands were cut (ε_{bed}) and after the girders were removed off the casting bed (ε_{move}).

Table 6.13 Average strain values for wax1 and wax2

Ref. Name	Beam	End	Side	ε_{bed}	ε_{move}	Avg. ε_{bed}	Avg. ε_{move}	$\varepsilon_{bed}/\varepsilon_{move}$	% ε_{add} from Move
Wax1	17-16.1	East	North	-0.00033	-0.00050	-0.00030	-0.00047	63%	59%
		East	South	-0.00026	-0.00044	-	-	-	-
		West	North	-0.00053	-0.00065	-0.00041	-0.00053	77%	29%
		West	South	-0.00029	-0.00041	-	-	-	-
Wax2	17-10.5	East	North	-0.00032	-0.00044	-0.00032	-0.00047	68%	47%
		East	South	-0.00032	-0.00050	-	-	-	-
		West	North	-0.00074	-0.00082	-0.00073	-0.00088	83%	21%
		West	South	-0.00071	-0.00093	-	-	-	-

Average strain values for both ε_{bed} and ε_{move} were found by averaging the strains calculated on the same end of the girder.

Table 6.14 shows the camber of the girder after the prestressing strands were cut, after the girder was removed from the casting bed, and the change in total length of the girder.

Table 6.14 Camber and length change for wax1 and wax2

Ref. Name	Beam	ΔL (in)	Δ_{bed} (in)	Δ_{move} (in)	$\Delta_{bed}/\Delta_{move}$	% Δ_{add} from Move
Wax1	17-16.1	2.81	2.22	3.27	68%	47%
Wax2	17-10.5	1.56	2.16	3.51	62%	63%

The length change of each girder was found using field measurements for the distance each end of the girder moved along the bed found in Table F.2 in Appendix F.

Table 6.15 shows a quantitative analytical summary of the performance of the teflon pad and Table 6.16 shows the coefficient of variation for those measured values.

Table 6.15 Performance summary for wax1 and wax2

Ref. Name	Weight (kip)	Hor. Force (kip)	Avg. % ε_{add} from Move	Avg. $\varepsilon_{bed}/\varepsilon_{move}$	ΔL (in)	% Δ_{add} from Move	Avg. $\Delta_{bed}/\Delta_{move}$
Wax1	95.39	1460.70	44%	70%	2.81	47%	68%
Wax2	97.01	1460.70	34%	75%	1.56	63%	62%

Table 6.16 Coefficients of variation for wax1 and wax2

Ref. Name	C_v ε_{bed}	C_v ε_{move}	C_v ΔL	C_v Δ_{bed}	C_v Δ_{move}
Wax1	35%	21%	40%	2%	5%
Wax2	45%	36%			

From the information in Table 6.15, using the wax lubricant as the friction reducing technique exhibited moderate frictional restraint between the ends of the girder and the casting bed. The additional compressive strain in the girders after the girders were moved off the casting bed ranged from 34% to 44% and the additional camber in the girders after the girders were moved off the casting bed ranged from 47% to 63%. These values were in the middle of the five

friction reducing techniques. The length change ranged from 1.56 in. to 2.81 in., which was the greatest among the five friction reducing techniques.

The ratios of $\varepsilon_{bed}/\varepsilon_{move}$ and $\Delta_{bed}/\Delta_{move}$ ranged from 70% to 75% and 62% to 68%, respectively. Having a $\varepsilon_{bed}/\varepsilon_{move}$ and $\Delta_{bed}/\Delta_{move}$ ratio equal to 100% means that there was no additional strain or camber induced in the girders after they were moved off the casting bed. In other words, there was no frictional restraint between the steel casting bed and the ends of the girder. Table 6.15 was compiled with the other friction reducing techniques' summaries into Table 6.29, presented in Section 6.8.

From the information in Table 6.16, the coefficients of variation between the measurements taken were moderate. The coefficient of variation for ΔL, Δ_{bed}, and Δ_{move} were found by using the values for both of the girders, which was why there was only one value for the friction reducing technique.

6.5 Plate1 and Plate2

Plate1 and plate2 were the girders that had the steel embedded plate at the ends of the girder shown in Figures 6.13 and 6.14. All steel plates had oil applied to the steel bed before the plates were placed on the bed. Field information for DEMEC readings, total station readings, strand tensioning, concrete properties, and mix designs for plate1 and plate2 are found in Appendices B through E, respectively. Table 6.17 shows the field information for plate1 and plate2. The length was taken as the in-plane length from plan sheets provided by Standard Concrete Products.

Table 6.17 Beam field information for plate1 and plate2

Beam Designation	Date Cast	Beam on Bed	Length	Weight (kip)	Horizontal Force (kip)	Friction Reducing Technique	Reference Name
19-20.2	10/4/06	3	124'-4 1/8"	96.75	1355.70	Steel Plate	Plate1
19-20.3	10/6/06	1	124'-4 1/8"	98.09	1357.50	Steel Plate	Plate2

The embedded steel plate was placed at both ends of the girder before the prestressing strands were pulled through the plywood forms on the ends. The embedded steel plate was originally designed for BT-54 girders, having a center of bearing of 7 in. Meaning the center of the pin and slotted hole on the plate needed to be 7 in. from the end of the plate as specified by the Georgia Department of Transportation and Moreland Altobelli Associates. Due to complications that arose, span 10, which was originally agreed upon to use for this project, had to be changed to the various spans used for this project. All the girders used in this project were BT-72's, having a specified center of bearing of 8 in. A 1 in. wide piece of plywood with chamfered ends was placed between the girder forms and the plate to move the center of bearing to the specified 8 in. Figure 6.13 shows the steel plate and 1 in. plywood after the prestressing strands were pulled and Figure 6.14 shows the steel plate and 1 in. plywood with shear reinforcement.

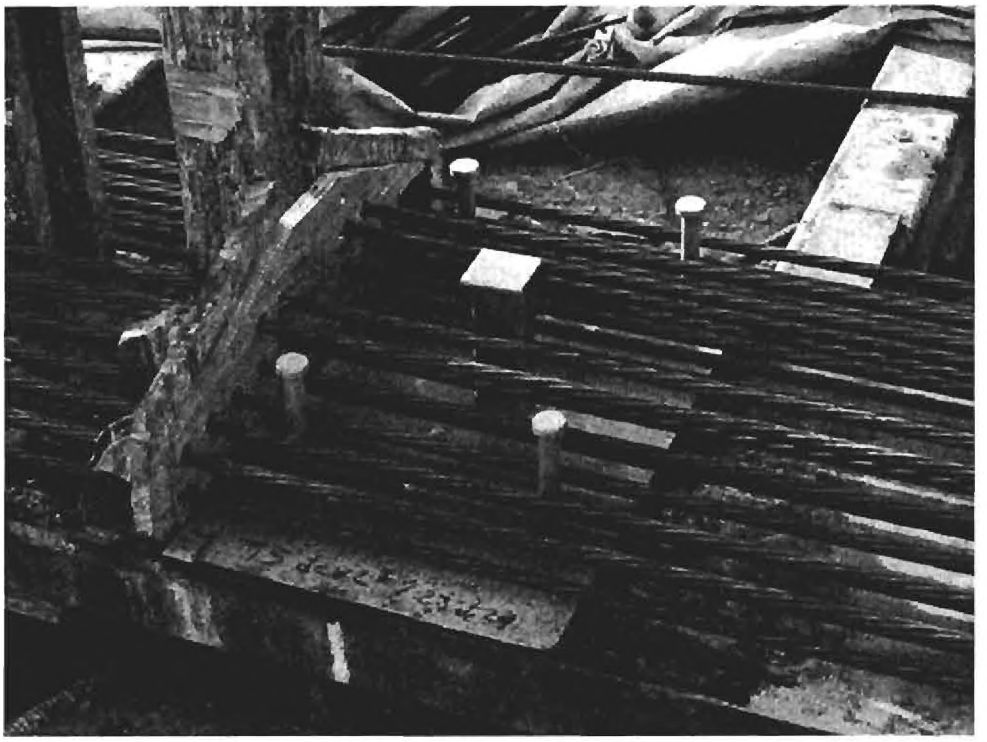


Figure 6.13 Steel plate and 1-in. plywood with prestressing strands pulled for plate1

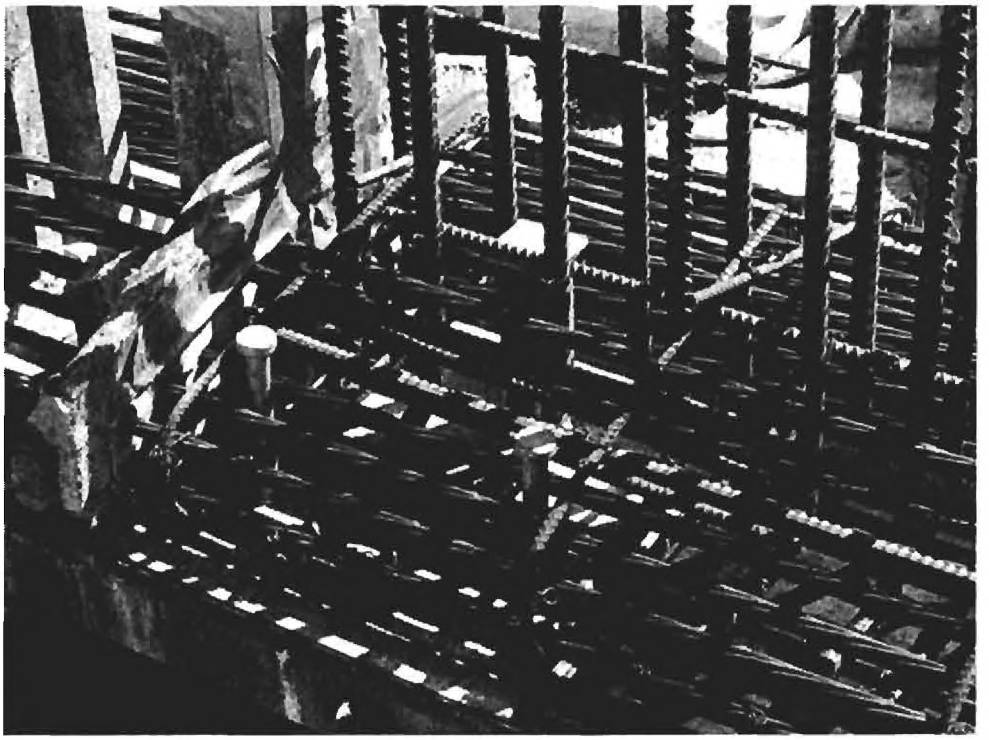


Figure 6.14 Steel plate and 1-in. plywood with shear reinforcement for plate1

Plate1 and plate2 exhibited no frictional tensile cracking at any of the four corners of their respective girders. Figures 6.15 and 6.16 show a typical uncracked corner of plate1 and plate2, respectively.

Figure 6.15 Uncracked southeast corner of plate1

Figure 6.16 Uncracked southeast corner of plate2

Table 6.18 shows the average strain values at both ends of the girders after the prestressing strands were cut (ε_{bed}) and after the girders were removed off the casting bed (ε_{move}).

Table 6.18 Average strain values for plate1 and plate2

Ref. Name	Beam	End	Side	ε_{bed}	ε_{move}	Avg. ε_{bed}	Avg. ε_{move}	$\varepsilon_{bed}/\varepsilon_{move}$	% ε_{add} from Move
Plate1	19-20.2	East	North	-0.00035	-0.00043	-0.00042	-0.00050	84%	19%
		East	South	-0.00048	-0.00056	-	-	-	-
		West	North	-0.00042	-0.00050	-0.00052	-0.00060	87%	16%
		West	South	-0.00061	-0.00069	-	-	-	-
Plate2	19-20.3	East	North	-0.00056	-0.00065	-0.00061	-0.00074	82%	21%
		East	South	-0.00065	-0.00082	-	-	-	-
		West	North	-0.00056	-0.00074	-0.00055	-0.00071	78%	28%
		West	South	-0.00054	-0.00067	-	-	-	-

Average strain values for both ε_{bed} and ε_{move} were found by averaging the strains calculated on the same end of the girder.

Table 6.19 shows the camber of the girder after the prestressing strands were cut, after the girder was removed from the casting bed, and the change in total length of the girder.

Table 6.19 Camber and length change for plate1 and plate2

Ref. Name	Beam	ΔL (in)	Δ_{bed} (in)	Δ_{move} (in)	$\Delta_{bed}/\Delta_{move}$	% Δ_{add} from Move
Plate1	19-20.2	1.56	2.88	3.18	91%	10%
Plate2	19-20.3	1.41	2.88	-	-	-

The length change of each girder was found using field measurements for the distance each end of the girder moved along the bed found in Tables F.3 and F.4 in Appendix F. Data for plate2 wasn't able to be collected due to complications that arose at Standard Concrete Products at the time the girder was moved off the casting bed.

Table 6.20 shows a quanitative analytical summary of the performance of the steel embedded plate and Table 6.21 shows the coefficient of variation for those measured values.

Table 6.20 Performance summary for plate1 and plate2

Ref. Name	Weight (kip)	Hor. Force (kip)	Avg. % ε_{add} from Move	Avg. $\varepsilon_{bed}/\varepsilon_{move}$	ΔL (in)	% Δ_{add} from Move	Avg. $\Delta_{bed}/\Delta_{move}$
Plate1	96.75	1355.70	17%	85%	1.56	10%	91%
Plate2	98.09	1357.50	25%	80%	1.41	-	-

Table 6.21 Coefficients of variation for plate1 and plate2

Ref. Name	C_v ε_{bed}	C_v ε_{move}	C_v ΔL	C_v Δ_{bed}	C_v Δ_{move}
Plate1	24%	20%	7%	0%	-
Plate2	9%	11%			

From the information in Table 6.20, using the embedded steel plate exhibited low frictional restraint between the ends of the girder and the casting bed. The additional compressive strain in the girders after the girders were moved off the casting bed ranged from 17% to 25% and the additional camber in the girders after the girders were moved off the casting

bed was 10%. These values were in the lowest of the five friction reducing techniques, next to the embedded steel angle. The length change ranged from 1.41 in. to 1.56 in., which was the greatest of the five friction reducing techniques, next to the wax lubricant.

The ratios of $\varepsilon_{bed}/\varepsilon_{move}$ and $\Delta_{bed}/\Delta_{move}$ ranged from 80% to 85% and 91%, respectively. Having a $\varepsilon_{bed}/\varepsilon_{move}$ and $\Delta_{bed}/\Delta_{move}$ ratio equal to 100% means that there was no additional strain or camber in the girders after they were moved off the casting bed. In other words, there was no frictional restraint between the steel casting bed and the ends of the girder. Table 6.20 was compiled with the other friction reducing techniques' summaries into Table 6.29, presented in Section 6.8.

From the information in Table 6.21, the coefficients of variation between the measurements taken were the lowest of the friction reducing techniques. The coefficient of variation for ΔL, Δ_{bed}, and Δ_{move} were found by using the values for both of the girders, which was why there was only one value for the friction reducing technique.

6.6 Angle1 and Angle2

Angle1 and angle2 were girders with the embedded steel angle at the ends of the girder shown in Figures 6.17 and 6.18. Oil was swabbed on the steel beds and beneath the angles before the concrete was placed. Field information for DEMEC readings, total station readings, strand tensioning, concrete properties, and mix designs for angle1 and angle2 are found in Appendices B through E, respectively. Table 6.22 shows the field information for angle1 and angle2. The length was taken as the in-plane length from plan sheets provided by Standard Concrete Products.

Table 6.22 Beam field information for angle1 and angle2

Beam Designation	Date Cast	Beam on Bed	Length	Weight (kip)	Horizontal Force (kip)	Friction Reducing Technique	Reference Name
19-19.5	10/4/06	1	124'-4 1/4"	92.30	1355.70	Steel Angle	Angle1
19-20.5	10/6/06	3	124'-4 1/8"	102.93	1357.50	Steel Angle	Angle2

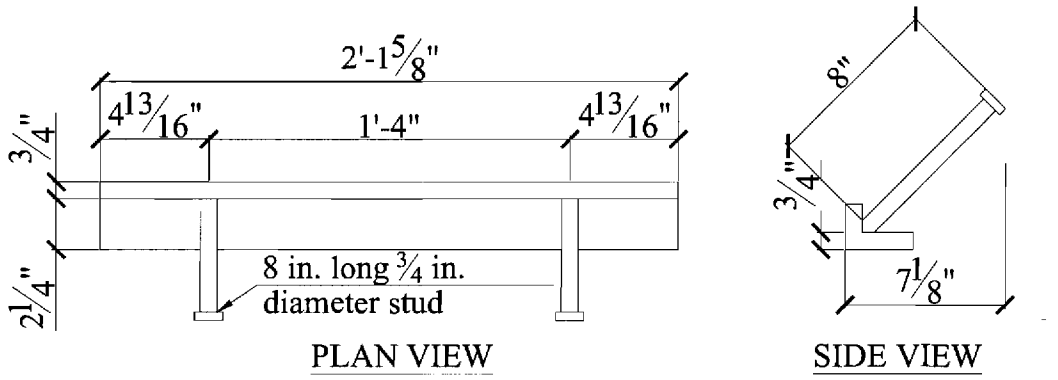


Figure 6.17 Plan and side view of embedded steel angle

The embedded steel angle was placed at both ends of the girder before the prestressing strands were pulled through the plywood forms on the ends. Figure 6.18 shows the steel angle before the prestressing strands were pulled, and Figure 6.19 shows the steel angle after the prestressing strands were pulled.

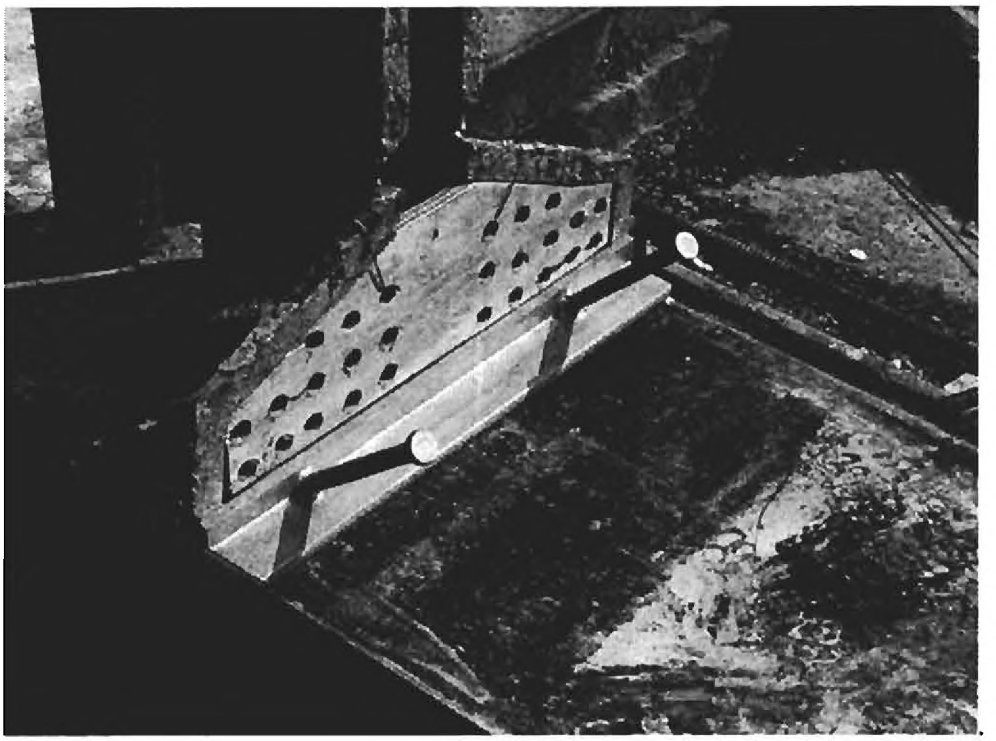


Figure 6.18 Steel angle before prestressing strands were pulled for angle1

Figure 6.19 Steel angle after prestressing strands were pulled for angle2

Angle1 exhibited a hairline crack at the southwest corner of the girder after the prestressing strands were cut. Angle2 exhibited no cracking at any of the four corners. Figure 6.20 shows the hairline crack in the southwest corner of angle1 and Figure 6.21 shows the uncracked southwest corner of angle2.

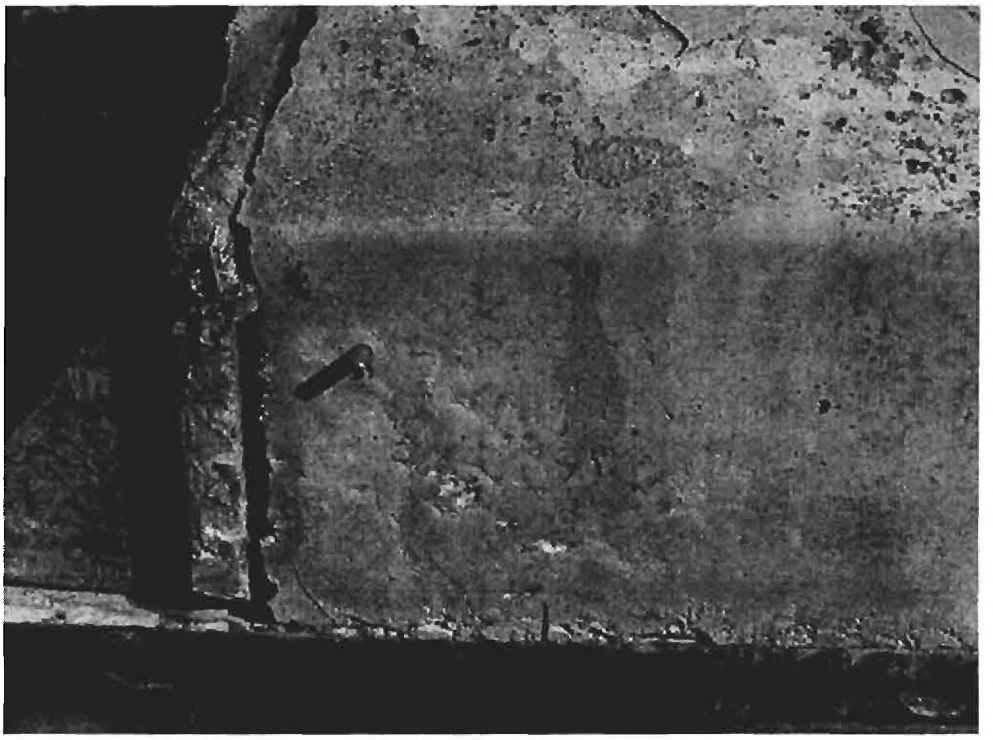


Figure 6.20 Hairline cracks at the southwest corner of angle1

Figure 6.21 Uncracked southwest corner of angle2

Table 6.23 shows the average strain values at both ends of the girders after the prestressing strands were cut (ε_{bed}) and after the girders were removed off the casting bed (ε_{move}).

Table 6.23 Average strain values for angle1 and angle2

Ref. Name	Beam	End	Side	ε_{bed}	ε_{move}	Avg. ε_{bed}	Avg. ε_{move}	$\varepsilon_{bed}/\varepsilon_{move}$	% ε_{add} from Move
Angle1	19-19.5	East	North	-0.00048	-0.00052	-0.00045	-0.00049	93%	8%
		East	South	-0.00042	-0.00045	-	-	-	-
		West	North	-0.00068	-0.00079	-0.00070	-0.00078	89%	12%
		West	South	-0.00071	-0.00077	-	-	-	-
Angle2	19-20.5	East	North	-0.00052	-0.00065	-0.00068	-0.00081	83%	20%
		East	South	-0.00083	-0.00097	-	-	-	-
		West	North	-0.00066	-0.00074	-0.00060	-0.00070	86%	16%
		West	South	-0.00054	-0.00065	-	-	-	-

Average strain values for both ε_{bed} and ε_{move} were found by averaging the strains calculated on the same end of the girder.

Table 6.24 shows the camber of the girder after the prestressing strands were cut, after the girder was removed from the casting bed, and the change in total length of the girder.

Table 6.24 Camber and length change for angle1 and angle2

Ref. Name	Beam	ΔL (in)	Δ_{bed} (in)	Δ_{move} (in)	$\Delta_{bed}/\Delta_{move}$	% Δ_{add} from Move
Angle1	19-19.5	1.41	2.88	3.09	93%	7%
Angle2	19-20.5	1.41	2.82	2.97	95%	5%

The length change of each girder was found using field measurements for the distance each end of the girder moved along the bed found in Table F.3 and F.4 in Appendix F.

Table 6.25 shows a quantitative analytical summary of the performance of the steel embedded angle and Table 6.26 shows the coefficient of variation for those measured values.

Table 6.25 Performance summary angle1 and angle2

Ref. Name	Weight (kip)	Hor. Force (kip)	Avg. % ε_{add} from Move	Avg. $\varepsilon_{bed}/\varepsilon_{move}$	ΔL (in)	% Δ_{add} from Move	Avg. $\Delta_{bed}/\Delta_{move}$
Angle1	96.75	1355.70	10%	91%	1.41	7%	93%
Angle2	98.09	1357.50	18%	85%	1.41	5%	95%

Table 6.26 Coefficients of variation angle1 and angle2

Ref. Name	C_v ε_{bed}	C_v ε_{move}	C_v ΔL	C_v Δ_{bed}	C_v Δ_{move}
Angle1	25%	27%	0%	1%	3%
Angle2	22%	20%			

From the information in Table 6.25, using the embedded steel angle exhibited low frictional restraint between the ends of the girder and the casting bed. The additional compressive strain in the girders after the girders were moved off the casting bed ranged from 10% to 18% and the additional camber in the girders after the girders were moved off the casting bed ranged from 5% to 7%. These values were the lowest of the five friction reducing

techniques. The length change was 1.41 in. for both girders, which was the third greatest of the five friction reducing techniques.

The ratios of $\varepsilon_{bed}/\varepsilon_{move}$ and $\Delta_{bed}/\Delta_{move}$ ranged from 85% to 91% and 93% to 95%, respectively. Having a $\varepsilon_{bed}/\varepsilon_{move}$ and $\Delta_{bed}/\Delta_{move}$ ratio equal to 100% means that there was no additional strain or camber induced in the girders after they were moved off the casting bed. In other words, there was no frictional restraint between the steel casting bed and the ends of the girder. Table 6.25 was compiled with the other friction reducing techniques' summaries into Table 6.29, presented in Section 6.8.

From the information in Table 6.26, the coefficients of variation between the measurements taken were the lowest of the friction reducing techniques. The coefficient of variation for ΔL, Δ_{bcd}, and Δ_{move} were found by using the values for both of the girders, which was why there was only one value for the friction reducing technique.

6.7 Cracked Section Calculations

Girders made with each of the friction reducing techniques exhibited bearing zone cracks after the prestressing strands were cut, except for the girders with the embedded steel plate. A calculation was made to verify that the stress caused by the friction force developed by the end of the girders was greater than the tension stress capacity of the concrete. Figure 6.22 illustrates the mechanism of the end crack.

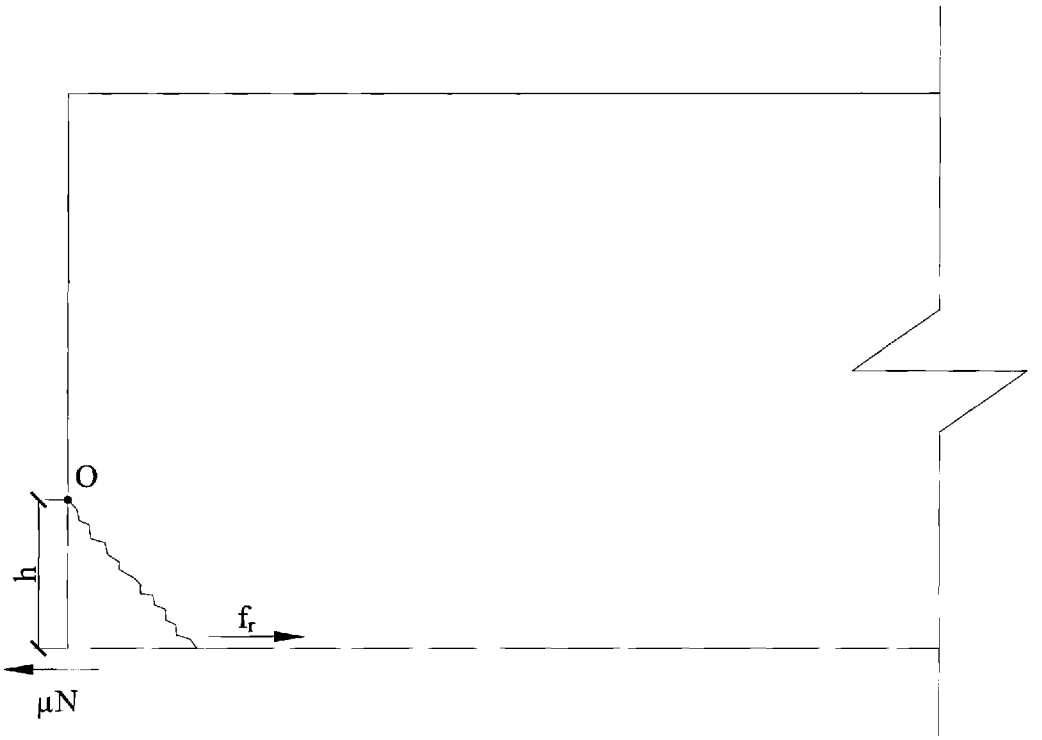


Figure 6.22 Crack and forces at end of girders

The stress caused by the friction force was calculated as follows:

$$\sum M_o = \mu N * h = 0$$

$$f_f = M_o / S < f_r$$

where: $\mu = \mu_{ave}$ found in Section 4.8 for each friction reducing technique

N = half the girder weight (bearing load at each end)

h = approximate average height of crack for each girder as measured

M_o = moment about the "h" height

$S = bh^2/3$ (section modulus below the crack about the base of the section)

b = width of the bottom flange (26 in. for all)

f_r = tension stress capacity of concrete (both $3\sqrt{f'_{ci}}$ and $7.5\sqrt{f'_{ci}}$ were checked)

f'_{ci} = girder compressive strength at the time strands were cut (Appendix E)

Table 6.27 shows the information needed to calculate the values in Table 6.28.

Table 6.27 Friction and tension capacity information

Ref Name	μ	N (kip)	h (in)	S (in^3)	f'_{ci} (psi)	M_o (k*in)
None1	0.445	48.51	6	312	7600	129.5
None2	0.445	48.37	6	312	5900	129.2
Pad1	0.265	48.51	5	216.67	7500	64.3
Pad2	0.265	48.37	5	216.67	7500	64.1
Pad3	0.265	47.89	5	216.67	7500	63.4
Pad4	0.265	49.04	5	216.67	7700	65.0
Wax1	0.232	47.69	4	138.67	7600	44.3
Wax2	0.232	48.51	4	138.67	7600	45.0
Plate1	0.206	48.37	0	0	5900	0
Plate2	0.206	49.04	0	0	7700	0
Angle1	0.206*	48.38	4	138.67	5900	39.9
Angle2	0.206*	49.04	0	0	7700	0

* The friction value used for the steel angle was that found for the oiled steel plate in the laboratory tests because the materials were the same

Table 6.28 Friction and tension capacity load values

Ref Name	$f_f = M_o/S$ (psi)	$f_r = 7.5\sqrt{(f'_c)}$ (psi)	$f_r = 3\sqrt{(f'_c)}$ (psi)	Cracked?
None1	415	654	262	yes
None2	414	576	230	yes
Pad1	297	650	260	yes
Pad2	296	650	260	yes
Pad3	293	650	260	yes
Pad4	300	658	263	yes
Wax1	319	654	262	yes
Wax2	325	654	262	yes
Plate1	0	576	230	no
Plate2	0	658	263	no
Angle1	287	576	230	yes
Angle2	0	658	263	no

In all cases where cracks were developed, the stress caused by friction (f_f) exceeded the allowable initial tension stress capacity (f_r) of $3\sqrt{f'_{ci}}$ for prestressed concrete as per ACI 318[2] and AASHTO[3]. Reducing the coefficient of friction to the point where f_f was less than f_r would

prevent these cracks from developing. The embedded steel plate acted as longitudinal reinforcement to resist that friction force and prevent cracks from developing.

In this study, the BT-72 sections weighed about 778 lbs./ft. If the initial concrete strength f_{ci}' is taken as 7,500 psi, the depth of the crack is taken as 6 in., the width of the bottom flange is taken as the standard 26 in., and the coefficient of friction for an oiled steel bed form ($\mu = 0.445$), then the maximum N value found using the relations given above is 30,380 lbs. The total weight of the beam would be 60,760 lbs which would be equivalent to a 78-ft long BT-72. It is concluded that a girder weighing more than about 61 kips which is cast on a bed with only an oiled form would develop bearing zone cracks due to frictional restraint.

6.8 Conclusion from Field Experiments

Table 6.29 shows a collection of information presented in Sections 6.2 through 6.6. Table 6.30 shows the average values for each friction reducing technique, arranged from most friction to least friction.

Table 6.29 Performance summary of the five friction reducing techniques

Ref. Name	Weight (kip)	Hor. Force (kip)	Avg. % ε_{add} from Move	Avg. $\varepsilon_{bed}/\varepsilon_{move}$	ΔL (in)	% Δ_{add} from Move	Avg. $\Delta_{bed}/\Delta_{move}$
None1	97.01	1460.70	151%	50%	1.28	65%	61%
None2	96.75	1355.70	80%	56%	1.19	18%	85%
Pad1	97.01	1438.80	105%	50%	1.53	54%	65%
Pad2	96.75	1438.80	51%	66%	1.30	38%	72%
Pad3	95.77	1438.80	78%	56%	0.86	54%	65%
Pad4	98.09	1357.50	80%	56%	1.22	20%	83%
Wax1	95.39	1460.70	44%	70%	2.81	47%	68%
Wax2	97.01	1460.70	34%	75%	1.56	63%	62%
Plate1	96.75	1355.70	17%	85%	1.56	10%	91%
Plate2	98.09	1357.50	25%	80%	1.41	-	-
Angle1	96.75	1355.70	10%	91%	1.41	7%	93%
Angle2	98.09	1357.50	18%	85%	1.41	5%	95%

Table 6.30 Average performance summary for the five friction reducing techniques

Ref. Name	Avg. Weight (kip)	Avg. Hor. Force (kip)	Avg. % ε_{add} from Move	Avg. $\varepsilon_{bed}/\varepsilon_{move}$	ΔL (in)	Avg. % Δ_{add} from Move	Avg. $\Delta_{bed}/\Delta_{move}$
None	96.88	1408.20	115%	53%	1.23	42%	73%
Pad	96.90	1418.48	79%	57%	1.23	42%	71%
Wax	96.20	1460.70	39%	73%	2.19	55%	65%
Plate	97.42	1356.60	21%	83%	1.48	10%	91%
Angle	97.42	1356.60	14%	88%	1.41	6%	94%

All average values presented in Table 6.30 were calculated by adding the values in Table 6.29 and dividing by the number of girders that specific friction reducing technique was tested on. From these average values, a qualitative analysis can be conducted.

Frictional restraint was observed by means of measuring strain in the concrete after the prestressing strands were cut and after the girders were moved off the casting bed, length change after the prestressing strands were cut, and camber at the midspan after the prestressing strands were cut and after the girders were moved off the casting bed. By observing the additional compressive strain in the concrete and additional camber at the midspan, a qualitative analysis for each friction reducing technique was made.

All of the friction reducing techniques that were used in the girders were compared to "None" which was the oiled coated steel bed – the control condition because an oil-coated surface is what is commonly used. The oil-coated surface showed the highest restraint to movement; it had the lowest $\varepsilon_{bed}/\varepsilon_{move}$ ratio, and the $\Delta_{bed}/\Delta_{move}$ ratio was nearly as low as that found for the girders with the teflon pads.

The teflon pad was the second least effective technique in limiting the additional strain in the girders after they were moved off the casting bed as determined by girder strain. The $\varepsilon_{bed}/\varepsilon_{move}$ ratio was 57%. It reduced the overall length of the girders the least, and was the second

least effective technique in limiting the additional camber in the girders after they were moved off the casting bed as determined by girder camber. The $\Delta_{bed}/\Delta_{move}$ ratio was 71%.

The wax lubricant was the third least effective technique in limiting the additional strain in the girders after they were moved off the casting bed as determined by girder strain. The $\varepsilon_{bed}/\varepsilon_{move}$ ratio was 73%. It reduced the overall length of the girders the greatest. However, the girders with the wax lubricant technique also had the greatest force from the prestressing strands, which may have caused this to occur. The wax lubricant was the least effective technique in limiting the additional camber in the girders after they were moved off the casting bed as determined by girder camber. The $\Delta_{bed}/\Delta_{move}$ ratio was 65%. On average, the wax lubricant may be judged equivalent to the teflon pad.

The embedded steel plate was the second most effective technique in limiting the additional strain in the girders after they were moved off the casting bed as determined by girder strain. The $\varepsilon_{bed}/\varepsilon_{move}$ ratio was 83%. It reduced the overall length of the girders the most, next to the wax lubricant, and was the second most effective technique in limiting the additional camber in the girders after they were moved off the casting bed as determined by girder camber. The $\Delta_{bed}/\Delta_{move}$ ratio was 91%. Comparing the $\varepsilon_{bed}/\varepsilon_{move}$ and $\Delta_{bed}/\Delta_{move}$ ratios of plate1 to none2 since they were cast in the same girder set, plate1 was 52% more effective in limiting the strain in the girders when they were moved off the casting bed and 7% more effective in limiting the camber in the girders when they were moved off the casting bed. Comparing the $\varepsilon_{bed}/\varepsilon_{move}$ ratios of plate2 to pad4 since they were cast in the same girder set, plate2 was 43% more effective in limiting the strain in the girders when they were moved off the casting bed. Camber could not be compared between plate2 and pad4 since camber readings were not able to be taken due to complications that arose at the precast plant.

The embedded steel angle was the most effective technique in limiting the additional strain in the girders after they were moved off the casting bed as determined by girder strain. The $\varepsilon_{bed}/\varepsilon_{move}$ ratio was 88%. It was similar to the embedded steel plate in reducing the overall length of the girders and was the most effective technique in limiting the additional camber in the girders after they were moved off the casting bed as determined by girder camber. The $\Delta_{bed}/\Delta_{move}$ ratio was 94%. Comparing the $\varepsilon_{bed}/\varepsilon_{move}$ and $\Delta_{bed}/\Delta_{move}$ ratios of angle1 to none2 since they were cast in the same girder set, angle1 was 63% more effective in limiting the strain in the girders when they were moved off the casting bed and 9% more effective in limiting the camber in the girders when they were moved off the casting bed. Comparing the $\varepsilon_{bed}/\varepsilon_{move}$ and $\Delta_{bed}/\Delta_{move}$ ratios of angle2 to pad4 since they were cast in the same girder set, angle2 was 52% more effective in limiting the strain in the girders when they were moved off the casting bed and 14% more effective in limiting the camber in the girders when they were moved off the casting bed.

The use of the teflon pad and wax lubricant were slightly better than using no friction reducing technique other than oil, which was evident by the information presented in Table 6.28. First, both the teflon pad and wax lubricant exhibited much smaller additional strain in the girders after they were moved off the casting bed compared to using no friction reducing technique. Consequently, the $\varepsilon_{bed}/\varepsilon_{move}$ value was higher for the teflon pad and wax lubricant as compared to using no friction reducing technique. Next, while the teflon pad had about the same changes in length as compared to having no friction reducing technique, the wax lubricant exhibited larger ΔL. Finally, the teflon pad and none's additional camber after the girder was moved off the casting bed were approximately the same, while the wax lubricant's was slightly higher. The differing relative results based on strain, length change, and camber between the

teflon pad and wax, lead to the conclusion that the techniques were about equivalent in reducing friction.

It was evident that the embedded steel plate and angle were the most successful in reducing the frictional restraint between the ends of the girders and the casting bed. Both techniques exhibited the greatest $\varepsilon_{bed}/\varepsilon_{move}$ and $\Delta_{bed}/\Delta_{move}$ ratios. Their ratios were: 83% and 88% for $\varepsilon_{bed}/\varepsilon_{move}$ and 91% and 94% for $\Delta_{bed}/\Delta_{move}$ for the steel embedded plate and angle, respectively.

From visual evidence displayed in Figures 6.15, 6.16, 6.20, and 6.21, it was apparent that the embedded steel angle and plate were nearly equal in reducing bearing zone cracking in prestressed concrete bridge girders. However, hairline cracks did develop in angle1 as shown in Figure 6.20.

It is believed hairline cracks did not develop in the girders with the embedded steel plate because the length of the plate was 3 in. and 13 in. from the end of the girders to the first and second studs. The first stud resisted some of the frictional force transferred from the start of the plate and the remainder of the friction force was resisted by the second stud. The embedded steel plate acted as a reinforcing bar to resist the tensile stress created when the end of the girder slid along the casting bed. Figure 6.23 shows the believed load path by the embedded steel plate to resist the friction force.

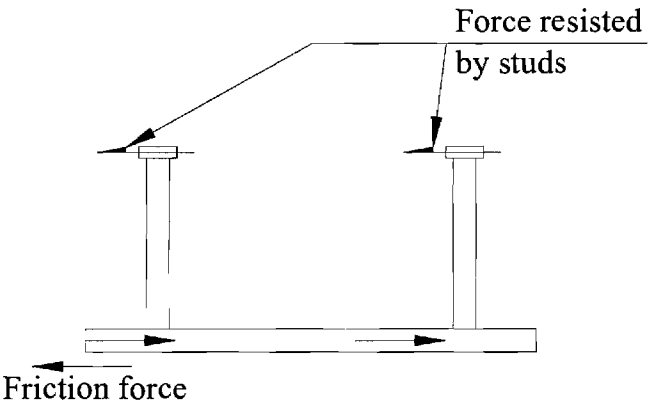


Figure 6.23 Load path through embedded steel plate

The concrete in this area was partially prestressed since the transfer length of the prestressing strands had begun to take place. This confined area of concrete was able to resist the frictional stresses created and prevent cracking in the bearing region of the girders.

The embedded steel angle was approximately 7 1/8 in. long from the end of the girders to the tip of the angled stud and the bottom leg of the angle was 3 in. from the end of the girder. The frictional force created at the ends of the girders when the ends slid along the casting bed was transferred from the end of the angle to the tip of the stud. Hairline cracks began to develop approximately 2 in. in and 4 in. up from the bottom corner and continue diagonally in the bottom flange, 3 in. in from the corner of angle1. These cracks crossed the plane where the welded studs were located within the section as shown in Figure 6.24. The angle was drawn in the photo where it was believed to be located within the section to show the cracks crossing the plane of the studs.

Figure 6.24 Hairline cracks crossing plane of angle1 stud

The stresses to create the hairline cracks were calculated as shown:

N = 0.5*96.75 kip (half the girder weight of angle1)

N = 48.375 kip

$F = \mu * N$

F = 0.206*48.375 kip ($\mu = \mu_{ave}$ from steel plate and oil technique in the Laboratory tests)

F = 9.97 kip

M = F*h (h was the distance from the bottom of the girder to top of crack)

$M = 9.97 \text{ kip}*(4 \text{ in})$

$M = 39.86 \text{ k}*\text{in}$

$f_f = M/S$ (S was section modulus below the point where crack starts)

$S = ((26 \text{ in.})*(4 \text{ in.})^2)/3$

$S = 138.67 \text{ in}^3$

$f_f = (39.86 \text{ k}*\text{in})/(138.67 \text{ in}^3)$

$f_f = 0.287 \text{ ksi}$

Applied stress checked against $3\sqrt{f'_{ci}}$ (the allowable tensile stress prestressed concrete)

$f_r = 3*\sqrt{(5900 \text{ psi})}$

$f_r = 0.230 \text{ ksi} < 0.287 \text{ ksi}$

Cracking occurred in girder angle1 but did not occur in angle2. This may be accounted in the difference in the compressive strengths at the time prestressing strands were cut. Angle2's strength was 7900 psi while angle1's release strength was 5900 psi, as shown in Appendix E.

The embedded steel plate helped to reduce frictional stresses and to prevent bearing zone cracking the greatest of the five friction reducing techniques.

CHAPTER VII

CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

From the results of the laboratory tests, the wax lubricant and teflon pad were approximately equivalent to the embedded steel plate on the bare steel sliding surface in reducing the sliding friction between the concrete block and steel surface. But the embedded steel plate and oil coated surface reduced the friction the greatest. The addition of the oil coated surface reduced friction on average by approximately 13.4%.

From the results of the field tests performed on BT-72 bridge girders at Standard Concrete Products, the teflon pad was the least effective technique in limiting the additional strain in the girders after they were moved off the casting bed as determined by girder strain. The ratio $\varepsilon_{bed}/\varepsilon_{move}$ was 57%. The pad reduced the overall length of the girders the least, and was the second least effective technique in limiting the additional camber in the girders after they were moved off the casting bed as determined by girder camber. The ratio $\Delta_{bed}/\Delta_{move}$ was 71%.

The wax lubircant was the second least effective technique in limiting the additional strain in the girders after they were moved off the casting bed as determined by girder strain. The ratio $\varepsilon_{bed}/\varepsilon_{move}$ was 73%. The wax reduced the overall length of the girders the greatest. However, the girders with the wax lubricant technique also had the greatest force from the prestressing strands, which may have caused this to occur. The wax lubricant was the least effective technique in limiting the additional camber in the girders after they were moved off the casting bed as determined by girder camber. The ratio $\Delta_{bed}/\Delta_{move}$ was 65%.

The embedded steel plate was the second most effective technique in limiting the additional strain in the girders after they were moved off the casting bed as determined by girder strain. The ratio $\varepsilon_{bed}/\varepsilon_{move}$ was 83%. It reduced the overall length of the girders the most, next to the wax lubricant, and was the second most effective technique in limiting the additional camber in the girders after they were moved off the casting bed as determined by girder camber. The ratio $\Delta_{bed}/\Delta_{move}$ was 91%.

The embedded steel angle was the most effective technique in limiting the additional strain in the girders after they were moved off the casting bed as determined by girder strain. The ratio $\varepsilon_{bed}/\varepsilon_{move}$ was 88%. It was similar to the embedded steel plate in reducing the overall length of the girders and was the most effective technique in limiting the additional camber in the girders after they were moved off the casting bed as determined by girder camber. The ratio $\Delta_{bed}/\Delta_{move}$ was 94%.

From the results of the field tests, the embedded steel plate and angle were the two most effective friction reducing techniques. Their differences in effectiveness may be caused by the slight variability of the data collecting method. Also, the embedded steel plate and angle also acted as a longitudinal reinforcement at the ends of the girder. Since the embedded steel plate was longer than the bottom leg of the embedded steel angle, the plate allowed the frictional force created when the girder slid along the casting bed to be transferred through the steel plate to the welded stud up to 13 inches into the girder. The confined concrete in this area was partially prestressed from the transfer of the force of the prestressing strand to the concrete. This prestressed concrete was able to resisted the frictional stresses and prevented cracks from developing.

The embedded steel angle had a 7 1/8 in. length to the end of the angled stud. The one hairline crack observed in the angle1 girder started at approximately 2 in. in and 4 in. up from the bottom corner of the girder and ended approximately 3 in. from the ends of the girder. This point was just beyond where the bottom leg of the embedded steel angle ended.

7.2 Recommendations

The wax lubricant proved to be as effective as the teflon pad in reducing the frictional restraint at the ends of the girders and the steel casting bed. Neither of these techniques was effective in reducing the bearing zone cracks from being created. Increasing the 2 in. length of the teflon pad would not increase its effectiveness in crack reduction or friction reduction since the girder ends stayed on the pad through the length change process.

The embedded steel plate and angle were nearly equivalent in reducing the frictional restraint at the ends of the girders and the steel casting bed. However, the embedded steel plate was more effective in reducing bearing zone cracking since the plate was longer and provided tensile resistance farther into the girder.

It is recommended that when constructing precast prestressed concrete bridge girders, a steel bearing plate should be embedded in each end of the girder to reduce the frictional restraint between the ends of the girder and the casting bed and to prevent bearing zone cracks from developing. The steel embedded angle could be implemented, but the length of the bottom leg of the angle would need to be increased.

Finally, it is recommended that when a girder weighs more than 61,000 lbs, a friction reducing technique should be used. In the case of a BT-72 girder such as used in this research, a friction reducing technique should be used for girders longer than 78 ft.

7.3 Future Research

As a result of this research project, some areas of additional research become noticeable.

The performance of the embedded steel plate and angle were almost equivalent in reducing the friction between the ends of the girder and the steel casting bed. However, cracks that developed using the embedded steel angle may have been caused by either the bottom leg of the angle or the welded studs not being long enough. Conducting tests on the use of longer studs and a longer bottom leg angle would be beneficial in order to incorporate the embedded steel angle into construction.

Long term serviceability effects of the embedded steel plate and angle are unknown. Conducting long term tests using a galvanized or stainless steel would help answer those questions. Comparative research of long term effects between the embedded steel angle and plate needs to be done to determine the effectiveness of the embedded steel plate and angle to long term serviceability of precast prestressed concrete bridge girders.

APPENDIX A

LABVIEW DATA TABLES FROM LABORATORY EXPERIMENT

This Appendix contains tables created in Excel that were generated from the National Instruments DAQ system. The tables in this Appendix were used to create Figures 4.1 through 4.6, 4.8 through 4.13, and 4.16 through 4.41. Initial reading tables were produced from the raw data given by the National Instruments DAQ system. Zeroed reading tables were created by taking the lowest reading, the first data reading, and subtracting that value from each data point taken during the test. The average potentiometer reading tables were produced by adding pot1 and pot2 on the zeroed reading tables and dividing by two.

Table A.1 Initial and zeroed readings for control test 1

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
0.13	1.610	2.072	2.061	0.00	0.000	0.000	0.000	0.000
0.15	1.610	2.071	2.061	0.02	0.000	0.001	0.000	0.000
0.18	1.610	2.071	2.061	0.06	0.000	0.001	0.000	0.001
0.13	1.610	2.072	2.061	0.00	0.000	0.000	0.000	0.000
0.17	1.610	2.071	2.061	0.04	0.000	0.000	0.000	0.000
0.13	1.610	2.072	2.061	0.00	0.000	0.000	0.000	0.000
0.19	1.610	2.072	2.061	0.06	0.000	0.000	0.000	0.000
0.83	1.610	2.072	2.061	0.71	0.000	0.000	0.000	0.000
0.34	1.610	2.072	2.061	0.21	0.000	0.000	0.000	0.000
0.82	1.609	2.072	2.061	0.69	0.000	0.000	0.000	0.000
0.34	1.610	2.071	2.061	0.22	0.000	0.000	0.000	0.000
24.12	1.609	2.064	2.048	24.00	0.001	0.008	0.013	0.010
47.01	1.610	2.055	2.042	46.89	0.000	0.016	0.019	0.018
120.57	1.609	2.052	2.042	120.44	0.000	0.019	0.019	0.019
164.29	1.608	2.048	2.020	164.16	0.002	0.023	0.042	0.032
192.11	1.600	2.045	1.999	191.98	0.010	0.027	0.062	0.045
197.82	1.593	2.041	2.003	197.70	0.017	0.031	0.058	0.044
200.90	1.593	2.041	1.996	200.77	0.017	0.031	0.065	0.048
205.14	1.593	2.040	2.000	205.02	0.017	0.031	0.061	0.046
206.39	1.593	2.040	1.999	206.26	0.017	0.032	0.062	0.047
207.05	1.592	2.039	2.001	206.93	0.018	0.033	0.060	0.047
207.32	1.592	2.037	2.001	207.20	0.018	0.034	0.061	0.048
207.57	1.592	2.038	2.001	207.45	0.018	0.034	0.060	0.047
207.70	1.592	2.037	2.002	207.57	0.018	0.035	0.059	0.047
207.86	1.592	2.038	2.003	207.74	0.017	0.034	0.058	0.046
207.95	1.592	2.037	2.003	207.82	0.018	0.035	0.058	0.047
208.14	1.592	2.037	2.003	208.01	0.017	0.035	0.058	0.047
219.55	1.586	2.033	1.990	219.42	0.024	0.038	0.072	0.055
235.18	1.578	2.025	1.978	235.06	0.032	0.046	0.084	0.065
221.42	1.564	2.014	1.960	221.29	0.046	0.058	0.101	0.079
218.01	1.551	1.998	1.940	217.88	0.059	0.073	0.121	0.097
213.08	1.536	1.982	1.923	212.96	0.074	0.090	0.138	0.114
220.28	1.523	1.966	1.895	220.15	0.087	0.105	0.166	0.136
232.33	1.511	1.952	1.895	232.21	0.099	0.120	0.166	0.143
242.65	1.498	1.935	1.879	242.52	0.112	0.137	0.182	0.160
246.97	1.483	1.919	1.866	246.84	0.127	0.153	0.195	0.174
252.71	1.469	1.904	1.838	252.58	0.141	0.168	0.223	0.195
253.02	1.455	1.888	1.833	252.89	0.155	0.183	0.228	0.206
242.33	1.444	1.877	1.820	242.21	0.166	0.195	0.242	0.218
232.23	1.441	1.869	1.816	232.10	0.169	0.202	0.245	0.224
242.75	1.442	1.872	1.815	242.62	0.168	0.200	0.246	0.223
241.36	1.441	1.873	1.816	241.23	0.169	0.199	0.246	0.222
241.36	1.442	1.873	1.816	241.23	0.168	0.199	0.245	0.222

Table A.1 Initial and zeroed readings for control test 1 (continued)

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
243.87	1.441	1.873	1.816	243.75	0.168	0.199	0.245	0.222
244.43	1.442	1.873	1.816	244.31	0.168	0.199	0.246	0.222
245.64	1.442	1.873	1.816	245.51	0.168	0.198	0.245	0.222
247.59	1.442	1.873	1.816	247.47	0.168	0.199	0.245	0.222
251.90	1.442	1.873	1.816	251.77	0.168	0.198	0.245	0.222
222.77	1.430	1.860	1.786	222.65	0.180	0.211	0.275	0.243
220.44	1.417	1.843	1.784	220.32	0.193	0.228	0.277	0.253
226.74	1.402	1.822	1.770	226.62	0.208	0.250	0.291	0.271
229.80	1.387	1.760	1.748	229.67	0.223	0.311	0.314	0.313
235.79	1.370	1.793	1.731	235.66	0.240	0.279	0.330	0.304
235.62	1.355	1.766	1.717	235.49	0.255	0.305	0.344	0.325
235.64	1.338	1.749	1.695	235.51	0.272	0.323	0.366	0.344
238.38	1.322	1.735	1.680	238.26	0.288	0.337	0.382	0.359
240.50	1.306	1.713	1.661	240.38	0.304	0.359	0.400	0.380
240.13	1.291	1.705	1.644	240.01	0.319	0.367	0.417	0.392
241.52	1.279	1.697	1.631	241.40	0.331	0.374	0.431	0.402
229.22	1.274	1.689	1.626	229.09	0.336	0.382	0.436	0.409
235.91	1.274	1.690	1.626	235.78	0.336	0.382	0.435	0.408
243.37	1.274	1.690	1.626	243.25	0.336	0.381	0.435	0.408
245.74	1.274	1.690	1.626	245.62	0.336	0.382	0.435	0.408
249.69	1.274	1.690	1.626	249.57	0.336	0.382	0.435	0.408
253.12	1.274	1.690	1.626	253.00	0.336	0.382	0.436	0.409
255.35	1.273	1.690	1.626	255.22	0.337	0.382	0.435	0.408
257.86	1.273	1.690	1.626	257.74	0.337	0.382	0.435	0.408
259.61	1.273	1.690	1.626	259.49	0.337	0.382	0.435	0.408
148.11	1.259	1.679	1.606	147.99	0.351	0.393	0.455	0.424
200.98	1.250	1.670	1.598	200.86	0.360	0.402	0.463	0.433
220.53	1.236	1.652	1.583	220.40	0.374	0.420	0.478	0.449
222.42	1.217	1.635	1.564	222.29	0.393	0.437	0.497	0.467
203.42	1.197	1.616	1.544	203.29	0.413	0.456	0.517	0.486
185.31	1.179	1.595	1.522	185.18	0.431	0.477	0.539	0.508
179.88	1.161	1.575	1.502	179.76	0.449	0.497	0.559	0.528
184.25	1.143	1.561	1.482	184.12	0.467	0.511	0.579	0.545
177.05	1.124	1.542	1.462	176.93	0.486	0.530	0.600	0.565
178.90	1.111	1.524	1.443	178.78	0.499	0.547	0.619	0.583
160.48	1.096	1.511	1.427	160.36	0.514	0.561	0.634	0.597
187.59	1.096	1.511	1.427	187.47	0.514	0.561	0.634	0.597
196.26	1.096	1.510	1.427	196.14	0.514	0.562	0.634	0.598
201.48	1.096	1.510	1.426	201.36	0.514	0.562	0.635	0.598
205.83	1.095	1.509	1.427	205.70	0.515	0.563	0.635	0.599
207.78	1.094	1.508	1.427	207.66	0.516	0.563	0.634	0.599
209.11	1.084	1.509	1.427	208.99	0.526	0.563	0.634	0.599
210.01	1.054	1.508	1.427	209.88	0.556	0.564	0.634	0.599

Table A.1 Initial and zeroed readings for control test 1 (continued)

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
210.67	1.030	1.507	1.427	210.55	0.580	0.565	0.634	0.600
211.23	1.023	1.507	1.427	211.11	0.587	0.565	0.634	0.599
155.66	1.009	1.494	1.412	155.54	0.601	0.577	0.649	0.613
189.74	0.998	1.483	1.400	189.61	0.612	0.589	0.661	0.625
151.11	0.978	1.463	1.377	150.98	0.632	0.609	0.684	0.647
175.43	0.959	1.446	1.357	175.31	0.650	0.626	0.704	0.665
174.89	0.941	1.428	1.335	174.77	0.668	0.644	0.726	0.685
151.75	0.920	1.408	1.314	151.63	0.690	0.663	0.747	0.705
165.16	0.901	1.391	1.295	165.04	0.709	0.681	0.766	0.723
172.96	0.883	1.373	1.275	172.83	0.727	0.699	0.786	0.742
164.29	0.864	1.358	1.257	164.16	0.746	0.714	0.804	0.759
164.48	0.848	1.342	1.240	164.35	0.762	0.730	0.821	0.775
169.49	0.835	1.328	1.228	169.36	0.775	0.744	0.834	0.789
185.70	0.834	1.328	1.227	185.58	0.776	0.743	0.834	0.789
197.35	0.834	1.329	1.224	197.22	0.776	0.743	0.837	0.790
200.71	0.834	1.329	1.224	200.59	0.776	0.743	0.837	0.790
205.04	0.834	1.329	1.225	204.91	0.776	0.743	0.837	0.790
207.74	0.834	1.329	1.225	207.61	0.776	0.743	0.837	0.790
209.24	0.834	1.329	1.224	209.11	0.776	0.743	0.837	0.790
210.42	0.834	1.328	1.224	210.30	0.776	0.744	0.837	0.790
211.21	0.834	1.327	1.225	211.09	0.776	0.745	0.837	0.791
211.73	0.834	1.327	1.224	211.61	0.776	0.745	0.837	0.791
167.78	0.814	1.306	1.206	167.66	0.796	0.766	0.855	0.811
203.19	0.799	1.293	1.187	203.06	0.811	0.779	0.875	0.827
172.96	0.777	1.273	1.165	172.83	0.833	0.799	0.896	0.848
181.69	0.758	1.246	1.144	181.56	0.852	0.826	0.917	0.871
184.64	0.736	1.217	1.121	184.52	0.874	0.855	0.940	0.897
168.53	0.715	1.209	1.102	168.40	0.895	0.862	0.959	0.911
171.82	0.695	1.121	1.082	171.69	0.915	0.951	0.979	0.965
192.58	0.677	1.179	1.065	192.46	0.933	0.893	0.996	0.945
200.05	0.658	1.158	1.045	199.92	0.952	0.914	1.017	0.965
181.46	0.640	1.115	1.028	181.34	0.970	0.957	1.034	0.995
203.75	0.639	1.137	1.026	203.62	0.971	0.935	1.035	0.985
205.49	0.638	1.141	1.026	205.37	0.972	0.931	1.035	0.983
208.93	0.638	1.140	1.026	208.80	0.972	0.932	1.035	0.984
211.44	0.638	1.141	1.026	211.31	0.972	0.931	1.035	0.983
213.62	0.638	1.140	1.026	213.50	0.972	0.932	1.035	0.984
215.76	0.638	1.140	1.025	215.64	0.972	0.932	1.036	0.984
217.68	0.638	1.140	1.025	217.55	0.972	0.932	1.036	0.984
219.28	0.638	1.140	1.026	219.15	0.972	0.932	1.036	0.984
220.32	0.638	1.140	1.026	220.19	0.972	0.932	1.036	0.984
137.95	0.622	1.123	1.011	137.82	0.988	0.948	1.050	0.999
200.21	0.610	1.113	0.997	200.09	1.000	0.959	1.065	1.012

Table A.1 Initial and zeroed readings for control test 1 (continued)

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
168.55	0.591	1.088	0.977	168.43	1.019	0.984	1.084	1.034
189.69	0.573	1.071	0.960	189.57	1.037	1.000	1.101	1.051
192.46	0.554	1.063	0.941	192.33	1.056	1.009	1.120	1.064
201.59	0.535	1.038	0.923	201.46	1.075	1.034	1.138	1.086
201.36	0.516	1.013	0.905	201.23	1.094	1.059	1.156	1.108
202.60	0.498	1.004	0.889	202.48	1.112	1.068	1.173	1.120
201.32	0.481	0.990	0.872	201.19	1.129	1.082	1.190	1.136
203.85	0.463	0.966	0.855	203.73	1.147	1.106	1.206	1.156
206.45	0.446	0.952	0.840	206.33	1.164	1.120	1.222	1.171
248.57	0.443	0.953	0.838	248.45	1.167	1.119	1.223	1.171
250.05	0.443	0.953	0.838	249.92	1.167	1.119	1.223	1.171
253.15	0.445	0.952	0.837	253.02	1.165	1.120	1.225	1.172
254.81	0.445	0.952	0.836	254.68	1.165	1.120	1.225	1.173
255.00	0.444	0.952	0.836	254.87	1.166	1.120	1.225	1.173
254.97	0.445	0.952	0.836	254.85	1.165	1.120	1.225	1.173
254.54	0.444	0.950	0.836	254.41	1.166	1.122	1.226	1.174
254.23	0.445	0.950	0.836	254.10	1.165	1.122	1.226	1.174
233.29	0.428	0.937	0.822	233.17	1.182	1.135	1.239	1.187
225.93	0.408	0.920	0.801	225.81	1.202	1.151	1.260	1.206
223.27	0.384	0.899	0.778	223.14	1.226	1.173	1.283	1.228
221.11	0.360	0.879	0.757	220.98	1.250	1.192	1.304	1.248
226.01	0.339	0.860	0.738	225.89	1.271	1.212	1.323	1.267
205.06	0.317	0.844	0.718	204.93	1.293	1.227	1.343	1.285
188.07	0.297	0.824	0.698	187.95	1.313	1.248	1.363	1.305
183.06	0.276	0.807	0.679	182.94	1.334	1.265	1.382	1.324
191.09	0.257	0.790	0.663	190.96	1.353	1.282	1.398	1.340
191.40	0.238	0.770	0.645	191.27	1.372	1.302	1.416	1.359
197.66	0.228	0.763	0.638	197.53	1.382	1.309	1.423	1.366
208.20	0.228	0.761	0.637	208.07	1.382	1.311	1.424	1.368
210.13	0.227	0.761	0.638	210.01	1.383	1.311	1.424	1.367
214.77	0.228	0.761	0.638	214.64	1.382	1.311	1.423	1.367
217.24	0.229	0.762	0.637	217.12	1.381	1.310	1.424	1.367
217.78	0.229	0.761	0.638	217.66	1.381	1.310	1.423	1.367
219.07	0.228	0.761	0.638	218.94	1.381	1.310	1.423	1.367
221.07	0.228	0.762	0.638	220.94	1.382	1.310	1.423	1.367
206.64	0.214	0.750	0.623	206.51	1.396	1.322	1.439	1.380
207.78	0.195	0.729	0.603	207.66	1.415	1.343	1.458	1.401
196.53	0.172	0.711	0.582	196.41	1.438	1.361	1.479	1.420
181.48	0.149	0.692	0.565	181.36	1.461	1.379	1.496	1.438
189.74	0.128	0.674	0.545	189.61	1.482	1.398	1.516	1.457
195.99	0.108	0.656	0.530	195.87	1.502	1.416	1.531	1.473
193.77	0.088	0.641	0.511	193.64	1.522	1.430	1.550	1.490
190.73	0.069	0.626	0.494	190.61	1.541	1.445	1.567	1.506

Table A.1 Initial and zeroed readings for control test 1 (continued)

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
188.57	0.055	0.609	0.477	188.45	1.555	1.463	1.584	1.524
191.19	0.043	0.591	0.460	191.07	1.566	1.481	1.601	1.541
216.39	0.035	0.578	0.448	216.26	1.575	1.494	1.613	1.554
232.27	0.036	0.575	0.448	232.15	1.574	1.497	1.613	1.555
240.61	0.036	0.575	0.448	240.48	1.574	1.497	1.613	1.555
245.45	0.035	0.574	0.448	245.33	1.575	1.498	1.613	1.555
246.49	0.035	0.574	0.447	246.37	1.575	1.497	1.614	1.556
245.97	0.036	0.574	0.447	245.85	1.574	1.497	1.614	1.556
246.12	0.036	0.574	0.447	245.99	1.574	1.497	1.614	1.556
246.41	0.036	0.574	0.448	246.28	1.574	1.498	1.614	1.556
247.12	0.035	0.575	0.448	246.99	1.575	1.497	1.614	1.555
243.62	0.026	0.558	0.431	243.50	1.584	1.513	1.630	1.572
267.14	0.014	0.539	0.412	267.01	1.596	1.532	1.649	1.591
268.68	0.000	0.515	0.389	268.55	1.610	1.557	1.672	1.615
238.97	-0.014	0.491	0.367	238.84	1.624	1.580	1.695	1.637
219.42	-0.027	0.473	0.347	219.30	1.637	1.599	1.715	1.657
212.40	-0.038	0.454	0.322	212.27	1.648	1.618	1.740	1.679
210.32	-0.049	0.437	0.311	210.19	1.659	1.635	1.750	1.693
204.27	-0.060	0.418	0.292	204.14	1.670	1.653	1.770	1.712
206.87	-0.073	0.401	0.279	206.74	1.683	1.671	1.782	1.727
203.60	-0.096	0.380	0.260	203.48	1.706	1.691	1.801	1.746
248.78	-0.100	0.379	0.261	248.65	1.710	1.693	1.801	1.747
248.82	-0.100	0.379	0.260	248.70	1.710	1.693	1.801	1.747
254.95	-0.100	0.379	0.260	254.83	1.710	1.693	1.801	1.747
260.98	-0.100	0.378	0.259	260.86	1.710	1.693	1.802	1.748
262.67	-0.100	0.379	0.258	262.54	1.710	1.693	1.803	1.748
262.52	-0.100	0.378	0.258	262.40	1.710	1.693	1.804	1.749
262.15	-0.100	0.379	0.257	262.02	1.710	1.693	1.804	1.749
262.04	-0.100	0.379	0.257	261.92	1.710	1.693	1.804	1.749
266.91	-0.100	0.378	0.257	266.78	1.710	1.693	1.804	1.749
243.44	-0.121	0.361	0.243	243.31	1.731	1.711	1.818	1.765
245.12	-0.143	0.347	0.230	244.99	1.753	1.725	1.831	1.778
243.75	-0.167	0.325	0.210	243.62	1.777	1.746	1.851	1.799
224.66	-0.193	0.309	0.197	224.54	1.803	1.763	1.865	1.814
206.74	-0.218	0.289	0.168	206.62	1.828	1.783	1.893	1.838
199.82	-0.241	0.269	0.147	199.69	1.851	1.803	1.914	1.859
196.95	-0.264	0.250	0.128	196.82	1.874	1.821	1.933	1.877
201.46	-0.287	0.231	0.111	201.34	1.897	1.841	1.950	1.896
223.91	-0.311	0.206	0.089	223.79	1.921	1.865	1.973	1.919
233.71	-0.332	0.187	0.069	233.58	1.942	1.885	1.992	1.939

Table A.2 Initial and zeroed readings for control test 2

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
0.13	1.685	2.084	2.035	0.00	0.000	0.000	0.000	0.000
0.44	1.685	2.084	2.034	0.32	0.000	0.000	0.000	0.000
0.59	1.685	2.084	2.034	0.46	0.000	0.000	0.001	0.000
0.60	1.685	2.084	2.034	0.48	0.000	0.000	0.000	0.000
0.44	1.685	2.084	2.034	0.31	0.000	0.000	0.000	0.000
0.32	1.685	2.084	2.034	0.20	0.000	0.000	0.001	0.000
0.69	1.685	2.084	2.034	0.57	0.000	0.000	0.001	0.000
0.29	1.685	2.084	2.034	0.17	0.000	0.000	0.000	0.000
0.82	1.685	2.084	2.034	0.69	0.000	0.000	0.001	0.000
5.04	1.685	2.081	2.034	4.91	0.000	0.002	0.001	0.001
62.63	1.684	2.070	2.025	62.50	0.001	0.014	0.010	0.012
150.57	1.681	2.064	2.016	150.44	0.004	0.020	0.018	0.019
166.33	1.673	2.060	1.991	166.20	0.012	0.024	0.043	0.034
171.94	1.662	2.046	1.982	171.81	0.023	0.038	0.053	0.045
175.60	1.651	2.037	1.976	175.47	0.034	0.047	0.059	0.053
182.79	1.640	2.025	1.957	182.67	0.045	0.059	0.078	0.069
160.42	1.629	2.013	1.953	160.30	0.056	0.071	0.082	0.077
178.95	1.628	2.008	1.952	178.82	0.057	0.076	0.083	0.080
186.20	1.628	2.007	1.952	186.08	0.057	0.077	0.083	0.080
187.28	1.628	2.009	1.952	187.16	0.057	0.075	0.083	0.079
189.47	1.628	2.009	1.952	189.34	0.057	0.075	0.083	0.079
190.57	1.628	2.009	1.953	190.44	0.057	0.075	0.082	0.078
191.54	1.628	2.009	1.953	191.42	0.057	0.074	0.082	0.078
192.29	1.628	2.009	1.952	192.17	0.057	0.075	0.082	0.079
192.79	1.628	2.009	1.952	192.67	0.057	0.075	0.082	0.079
193.19	1.628	2.009	1.952	193.06	0.057	0.075	0.082	0.079
193.64	1.628	2.009	1.952	193.52	0.057	0.074	0.082	0.078
224.93	1.627	2.009	1.947	224.81	0.058	0.075	0.088	0.081
195.62	1.625	2.003	1.943	195.49	0.060	0.081	0.092	0.086
119.67	1.618	1.997	1.941	119.55	0.067	0.087	0.094	0.091
146.72	1.618	1.997	1.940	146.60	0.067	0.087	0.095	0.091
134.37	1.606	1.983	1.902	134.25	0.079	0.101	0.133	0.117
179.90	1.596	1.975	1.912	179.78	0.089	0.109	0.123	0.116
202.33	1.582	1.959	1.900	202.21	0.102	0.125	0.135	0.130
142.79	1.570	1.944	1.885	142.67	0.115	0.139	0.150	0.145
157.30	1.569	1.941	1.883	157.18	0.116	0.143	0.152	0.147
198.28	1.568	1.941	1.882	198.15	0.116	0.143	0.152	0.147
216.91	1.568	1.936	1.883	216.78	0.117	0.147	0.152	0.150
186.64	1.566	1.941	1.878	186.51	0.119	0.143	0.157	0.150
221.15	1.555	1.920	1.870	221.02	0.130	0.164	0.165	0.164
208.34	1.540	1.908	1.855	208.22	0.145	0.176	0.180	0.178
200.26	1.527	1.892	1.837	200.13	0.158	0.192	0.197	0.195
189.76	1.512	1.876	1.810	189.63	0.173	0.208	0.225	0.216

Table A.2 Initial and zeroed readings for control test 2 (continued)

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
174.43	1.498	1.861	1.804	174.31	0.187	0.223	0.231	0.227
231.34	1.483	1.841	1.789	231.21	0.201	0.242	0.245	0.244
192.50	1.472	1.828	1.774	192.38	0.213	0.256	0.261	0.258
199.05	1.471	1.826	1.774	198.92	0.214	0.258	0.261	0.260
210.40	1.470	1.827	1.774	210.28	0.215	0.257	0.261	0.259
210.07	1.470	1.827	1.775	209.94	0.215	0.257	0.260	0.258
212.27	1.470	1.827	1.774	212.15	0.215	0.257	0.260	0.259
212.38	1.470	1.827	1.774	212.25	0.215	0.257	0.260	0.259
213.46	1.470	1.825	1.774	213.33	0.215	0.258	0.260	0.259
214.08	1.470	1.825	1.775	213.96	0.215	0.259	0.260	0.260
214.77	1.470	1.825	1.774	214.64	0.215	0.258	0.261	0.260
218.14	1.471	1.824	1.774	218.01	0.214	0.260	0.260	0.260
200.65	1.461	1.807	1.758	200.53	0.224	0.277	0.277	0.277
204.48	1.442	1.785	1.738	204.35	0.243	0.299	0.297	0.298
214.43	1.428	1.763	1.723	214.31	0.257	0.321	0.312	0.316
213.71	1.409	1.731	1.703	213.58	0.276	0.353	0.332	0.342
209.15	1.390	1.732	1.684	209.03	0.294	0.352	0.351	0.351
211.96	1.375	1.709	1.662	211.83	0.310	0.374	0.373	0.373
220.55	1.360	1.698	1.649	220.42	0.325	0.386	0.386	0.386
229.03	1.344	1.681	1.629	228.90	0.341	0.403	0.405	0.404
230.90	1.329	1.664	1.613	230.77	0.356	0.420	0.421	0.421
224.58	1.312	1.647	1.594	224.45	0.372	0.437	0.441	0.439
161.48	1.308	1.643	1.591	161.36	0.377	0.441	0.443	0.442
188.57	1.308	1.643	1.591	188.45	0.377	0.441	0.444	0.443
191.13	1.308	1.642	1.591	191.00	0.377	0.442	0.444	0.443
196.18	1.308	1.641	1.591	196.06	0.377	0.443	0.443	0.443
199.09	1.308	1.639	1.591	198.97	0.377	0.445	0.443	0.444
201.40	1.308	1.638	1.591	201.27	0.377	0.446	0.444	0.445
204.10	1.307	1.639	1.591	203.98	0.377	0.445	0.444	0.444
205.02	1.307	1.639	1.591	204.89	0.378	0.445	0.444	0.445
206.10	1.308	1.638	1.591	205.97	0.377	0.445	0.444	0.445
222.15	1.306	1.635	1.584	222.02	0.379	0.449	0.451	0.450
176.64	1.287	1.619	1.571	176.51	0.398	0.464	0.464	0.464
183.17	1.271	1.600	1.550	183.04	0.414	0.484	0.484	0.484
168.36	1.250	1.577	1.529	168.24	0.435	0.507	0.506	0.507
179.88	1.232	1.557	1.506	179.76	0.453	0.527	0.529	0.528
193.98	1.213	1.537	1.490	193.85	0.472	0.547	0.545	0.546
200.44	1.197	1.518	1.470	200.32	0.488	0.566	0.565	0.565
218.82	1.196	1.519	1 466	218.70	0.489	0.565	0.568	0.567
235.72	1.168	1.487	1.439	235.60	0.517	0.597	0.596	0.596
230.03	1.148	1.463	1.416	229.90	0.537	0.620	0.619	0.620
197.91	1.138	1.452	1.403	197.78	0.547	0.632	0.631	0.632
198.41	1.137	1.451	1.404	198.28	0.548	0.633	0.631	0.632

Table A.2 Initial and zeroed readings for control test 2 (continued)

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
197.99	1.137	1.451	1.404	197.86	0.548	0.633	0.631	0.632
201.90	1.137	1.451	1.404	201.77	0.548	0.633	0.631	0.632
203.83	1.136	1.451	1.403	203.71	0.549	0.633	0.631	0.632
169.03	1.133	1.448	1.400	168.90	0.552	0.636	0.635	0.635
169.67	1.132	1.448	1.400	169.55	0.553	0.636	0.635	0.635
170.34	1.131	1.448	1.400	170.21	0.554	0.636	0.635	0.636
170.90	1.118	1.448	1.400	170.77	0.567	0.636	0.635	0.635
173.21	1.090	1.448	1.400	173.08	0.595	0.636	0.635	0.635
201.09	1.067	1.448	1.400	200.96	0.618	0.636	0.635	0.636
218.01	1.063	1.446	1.399	217.88	0.622	0.638	0.635	0.637
164.58	1.042	1.426	1.382	164.45	0.643	0.657	0.653	0.655
170.59	1.023	1.409	1.362	170.46	0.662	0.675	0.673	0.674
142.17	1.004	1.387	1.342	142.04	0.681	0.697	0.693	0.695
156.56	0.985	1.366	1.320	156.43	0.700	0.718	0.715	0.716
154.98	0.967	1.346	1.304	154.85	0.717	0.738	0.731	0.734
177.10	0.950	1.329	1.286	176.97	0.735	0.754	0.749	0.752
160.96	0.932	1.308	1.268	160.84	0.752	0.775	0.767	0.771
179.01	0.914	1.291	1.248	178.88	0.771	0.793	0.787	0.790
161.75	0.895	1.271	1.229	161.63	0.790	0.812	0.806	0.809
142.38	0.879	1.256	1.216	142.25	0.806	0.828	0.819	0.823
162.06	0.878	1.254	1.214	161.94	0.807	0.830	0.821	0.825
167.45	0.878	1.253	1.212	167.32	0.807	0.831	0.822	0.826
174.50	0.878	1.254	1.213	174.37	0.807	0.830	0.822	0.826
178.16	0.878	1.254	1.213	178.03	0.807	0.830	0.822	0.826
180.80	0.878	1.254	1.213	180.67	0.807	0.830	0.822	0.826
182.92	0.878	1.253	1.212	182.79	0.807	0.831	0.823	0.827
184.08	0.878	1.253	1.212	183.96	0.807	0.831	0.822	0.826
185.25	0.878	1.253	1.213	185.12	0.807	0.831	0.822	0.826
186.31	0.878	1.254	1.213	186.18	0.807	0.830	0.822	0.826
223.33	0.880	1.251	1.212	223.21	0.805	0.833	0.822	0.828
186.76	0.863	1.233	1.193	186.64	0.822	0.851	0.842	0.846
162.69	0.843	1.214	1.173	162.56	0.842	0.870	0.862	0.866
162.48	0.827	1.192	1.149	162.35	0.858	0.892	0.886	0.889
169.61	0.806	1.160	1.137	169.49	0.879	0.924	0.898	0.911
186.95	0.789	1.142	1.120	186.82	0.896	0.942	0.914	0.928
191.07	0.769	1.138	1.102	190.94	0.916	0.946	0.932	0.939
186.47	0.751	1.118	1.084	186.35	0.934	0.966	0.950	0.958
175.58	0.729	1.101	1.065	175.45	0.956	0.983	0.970	0.977
187.95	0.713	1.078	1.048	187.82	0.972	1.006	0.986	0.996
155.04	0.691	1.061	1.028	154.91	0.994	1.023	1.007	1.015
186.39	0.689	1.027	1.026	186.26	0.996	1.057	1.009	1.033
193.69	0.688	1.051	1.026	193.56	0.997	1.033	1.009	1.021
194.95	0.688	1.055	1.026	194.83	0.997	1.028	1.009	1.019

Table A.2 Initial and zeroed readings for control test 2 (continued)

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
199.01	0.688	1.053	1.026	198.88	0.997	1.031	1.009	1.020
200.78	0.688	1.050	1.026	200.65	0.997	1.034	1.009	1.021
202.92	0.688	1.052	1.026	202.79	0.997	1.032	1.009	1.021
204.31	0.688	1.050	1.025	204.18	0.997	1.034	1.010	1.022
205.33	0.688	1.050	1.026	205.20	0.997	1.033	1.009	1.021
206.14	0.688	1.056	1.025	206.01	0.997	1.028	1.009	1.019
253.08	0.688	1.050	1.024	252.96	0.997	1.034	1.011	1.022
205.72	0.682	1.030	1.018	205.60	1.003	1.054	1.017	1.035
192.71	0.665	1.030	1.003	192.58	1.020	1.054	1.032	1.043
160.28	0.657	1.026	0.994	160.15	1.028	1.058	1.041	1.049
170.80	0.642	1.009	0.977	170.67	1.043	1.075	1.058	1.066
143.27	0.623	0.995	0.960	143.14	1.062	1.089	1.075	1.082
172.67	0.608	0.966	0.944	172.54	1.077	1.117	1.091	1.104
141.00	0.588	0.952	0.927	140.88	1.097	1.132	1.108	1.120
186.68	0.572	0.943	0.911	186.55	1.113	1.141	1.124	1.133
164.66	0.549	0.924	0.891	164.54	1.136	1.160	1.144	1.152
175.60	0.531	0.892	0.873	175.47	1.154	1.192	1.162	1.177
144.85	0.507	0.884	0.853	144.72	1.178	1.200	1.182	1.191
167.95	0.499	0.876	0.844	167.82	1.186	1.208	1.191	1.200
171.15	0.499	0.876	0.844	171.02	1.185	1.208	1.191	1.200
178.14	0.499	0.875	0.843	178.01	1.186	1.209	1.191	1.200
185.54	0.500	0.875	0.843	185.41	1.185	1.209	1.192	1.200
191.52	0.496	0.875	0.844	191.40	1.189	1.209	1.191	1.200
193.23	0.495	0.875	0.843	193.10	1.190	1.209	1.191	1.200
195.20	0.496	0.875	0.843	195.08	1.189	1.209	1.191	1.200
196.56	0.496	0.875	0.843	196.43	1.189	1.209	1.191	1.200
219.63	0.494	0.873	0.842	219.51	1.191	1.211	1.193	1.202
187.41	0.471	0.849	0.824	187.28	1.214	1.234	1.211	1.223
169.28	0.446	0.828	0.801	169.15	1.239	1.256	1.233	1.245
147.93	0.422	0.805	0.775	147.80	1.263	1.279	1.260	1.269
155.72	0.398	0.784	0.753	155.60	1.287	1.299	1.282	1.291
157.01	0.376	0.757	0.734	156.89	1.309	1.327	1.301	1.314
215.20	0.355	0.737	0.715	215.08	1.330	1.347	1.320	1.333
223.17	0.334	0.713	0.695	223.04	1.351	1.371	1.340	1.356
223.00	0.311	0.701	0.673	222.87	1.373	1.383	1.361	1.372
184.81	0.291	0.682	0.657	184.68	1.394	1.402	1.378	1.390
208.80	0.290	0.680	0.656	208.67	1.395	1.404	1.379	1.391
209.94	0.290	0.680	0.656	209.82	1.395	1.404	1.379	1.391
213.62	0.290	0.679	0.655	213.50	1.395	1.405	1.379	1.392
213.35	0.290	0.679	0.655	213.23	1.395	1.405	1.380	1.392
215.29	0.290	0.680	0.654	215.16	1.395	1.404	1.380	1.392
216.10	0.289	0.680	0.654	215.97	1.396	1.404	1.380	1.392
217.43	0.289	0.680	0.654	217.30	1.396	1.404	1.380	1.392

Table A.2 Initial and zeroed readings for control test 2 (continued)

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
217.99	0.289	0.680	0.654	217.86	1.396	1.404	1.381	1.392
222.44	0.289	0.680	0.654	222.31	1.396	1.404	1.381	1.392
161.46	0.268	0.658	0.636	161.34	1.417	1.426	1.398	1.412
178.76	0.251	0.645	0.621	178.63	1.433	1.439	1.414	1.426
145.97	0.228	0.626	0.603	145.85	1.457	1.458	1.432	1.445
182.65	0.210	0.606	0.583	182.52	1.475	1.478	1.451	1.465
195.33	0.189	0.589	0.564	195.20	1.496	1.495	1.471	1.483
187.66	0.168	0.571	0.545	187.53	1.517	1.513	1.489	1.501
192.98	0.148	0.551	0.530	192.85	1.537	1.532	1.505	1.519
213.23	0.129	0.536	0.513	213.10	1.556	1.548	1.522	1.535
222.60	0.109	0.516	0.496	222.48	1.576	1.568	1.539	1.553
226.43	0.088	0.500	0.478	226.30	1.597	1.584	1.556	1.570
183.79	0.071	0.485	0.464	183.66	1.614	1.599	1.571	1.585
194.64	0.070	0.485	0.464	194.52	1.615	1.599	1.571	1.585
201.92	0.070	0.485	0.464	201.79	1.615	1.599	1.571	1.585
197.59	0.070	0.484	0.464	197.47	1.615	1.599	1.571	1.585
199.94	0.070	0.484	0.464	199.82	1.615	1.600	1.571	1.585
200.23	0.068	0.484	0.464	200.11	1.617	1.600	1.571	1.586
200.90	0.068	0.484	0.464	200.77	1.617	1.600	1.571	1.585
201.88	0.068	0.484	0.464	201.75	1.617	1.600	1.571	1.585
202.56	0.068	0.484	0.464	202.44	1.617	1.600	1.571	1.585
252.11	0.068	0.484	0.463	251.98	1.617	1.600	1.571	1.586
194.83	0.053	0.461	0.451	194.70	1.632	1.623	1.584	1.604
192.83	0.042	0.441	0.434	192.71	1.643	1.642	1.601	1.622
158.72	0.028	0.422	0.404	158.59	1.656	1.662	1.630	1.646
153.96	0.017	0.402	0.388	153.83	1.667	1.682	1.646	1.664
129.67	0.006	0.385	0.372	129.55	1.679	1.699	1.663	1.681
133.58	-0.004	0.353	0.354	133.46	1.689	1.731	1.681	1.706
141.57	-0.014	0.352	0.319	141.44	1.699	1.732	1.716	1.724
150.75	-0.023	0.332	0.323	150.63	1.708	1.752	1.712	1.732
160.90	-0.033	0.322	0.307	160.77	1.718	1.761	1.728	1.745
171.07	-0.042	0.308	0.291	170.94	1.727	1.776	1.744	1.760
180.44	-0.052	0.292	0.279	180.32	1.737	1.792	1.756	1.774
191.84	-0.054	0.288	0.276	191.71	1.739	1.796	1.759	1.777
200.46	-0.054	0.288	0.276	200.34	1.739	1.796	1.758	1.777
203.50	-0.054	0.287	0.276	203.37	1.739	1.797	1.759	1.778
208.80	-0.054	0.288	0.276	208.67	1.739	1.796	1.759	1.777
211.52	-0.054	0.288	0.276	211.40	1.739	1.796	1.758	1.777
214.23	-0.054	0.289	0.276	214.10	1.739	1.795	1.759	1.777
215.87	-0.054	0.288	0.276	215.74	1.739	1.796	1.759	1.777
218.76	-0.054	0.289	0.276	218.63	1.739	1.795	1.759	1.777
219.96	-0.054	0.288	0.276	219.84	1.739	1.796	1.759	1.777
220.84	-0.054	0.289	0.276	220.71	1.739	1.795	1.758	1.777

Table A.2 Initial and zeroed readings for control test 2 (continued)

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
221.44	-0.054	0.289	0.276	221.31	1.739	1.795	1.759	1.777
229.94	-0.054	0.289	0.276	229.82	1.739	1.795	1.759	1.777
256.28	-0.054	0.286	0.276	256.16	1.739	1.797	1.759	1.778
192.77	-0.070	0.262	0.253	192.65	1.755	1.822	1.782	1.802
163.75	-0.095	0.238	0.238	163.62	1.780	1.846	1.797	1.822
171.00	-0.128	0.214	0.212	170.88	1.813	1.870	1.822	1.846
202.94	-0.158	0.189	0.187	202.81	1.843	1.894	1.848	1.871
273.94	-0.186	0.167	0.168	273.81	1.871	1.917	1.867	1.892
245.27	-0.213	0.144	0.147	245.14	1.898	1.940	1.887	1.914
200.11	-0.238	0.122	0.124	199.98	1.923	1.962	1.911	1.936
229.13	-0.254	0.112	0.115	229.01	1.938	1.972	1.920	1.946
240.11	-0.255	0.112	0.113	239.98	1.939	1.972	1.922	1.947

Table A.3 Initial and zeroed readings for control test 3

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
0.19	1.805	2.037	2.101	0.00	0.000	0.000	0.000	0.000
0.35	1.805	2.037	2.100	0.16	0.000	0.000	0.001	0.001
0.53	1.805	2.037	2.100	0.34	0.000	0.000	0.001	0.001
0.25	1.805	2.037	2.100	0.06	0.000	0.000	0.001	0.001
0.35	1.804	2.037	2.100	0.16	0.000	0.000	0.001	0.000
0.31	1.805	2.036	2.100	0.12	0.000	0.001	0.001	0.001
0.33	1.805	2.037	2.101	0.14	0.000	0.000	0.000	0.000
0.40	1.804	2.036	2.101	0.21	0.001	0.001	0.001	0.001
0.92	1.804	2.037	2.101	0.73	0.001	0.000	0.001	0.000
0.90	1.804	2.036	2.101	0.71	0.001	0.001	0.001	0.001
5.00	1.805	2.022	2.100	4.80	0.000	0.015	0.001	0.008
86.60	1.803	2.028	2.086	86.41	0.002	0.009	0.016	0.012
186.31	1.799	2.016	2.070	186.11	0.005	0.021	0.031	0.026
255.08	1.794	2.004	2.072	254.89	0.011	0.033	0.029	0.031
242.90	1.783	1.989	2.042	242.70	0.022	0.048	0.059	0.054
237.45	1.769	1.974	2.019	237.26	0.036	0.063	0.082	0.073
227.99	1.755	1.955	2.014	227.80	0.050	0.082	0.088	0.085
216.91	1.738	1.935	2.009	216.72	0.067	0.102	0.092	0.097
203.33	1.721	1.914	1.990	203.14	0.084	0.124	0.112	0.118
229.24	1.719	1.916	1.988	229.04	0.086	0.121	0.113	0.117
232.54	1.719	1.916	1.985	232.35	0.086	0.121	0.116	0.118
232.69	1.718	1.917	1.981	232.50	0.087	0.120	0.120	0.120
235.35	1.719	1.916	1.979	235.16	0.086	0.121	0.122	0.121
236.85	1.719	1.916	1.976	236.65	0.086	0.121	0.126	0.124
237.97	1.719	1.916	1.971	237.78	0.086	0.121	0.130	0.126
238.88	1.719	1.915	1.978	238.69	0.086	0.122	0.123	0.123
239.63	1.719	1.915	1.980	239.44	0.086	0.122	0.121	0.121
240.03	1.720	1.915	1.984	239.83	0.085	0.122	0.117	0.120
244.95	1.717	1.904	1.955	244.76	0.088	0.133	0.147	0.140
220.61	1.699	1.885	1.917	220.42	0.106	0.152	0.184	0.168
219.84	1.683	1.855	1.935	219.65	0.122	0.182	0.167	0.174
211.52	1.663	1.841	1.914	211.33	0.142	0.196	0.187	0.191
225.29	1.642	1.815	1.893	225.09	0.163	0.222	0.208	0.215
228.57	1.624	1.798	1.874	228.38	0.180	0.239	0.228	0.233
220.36	1.607	1.777	1.838	220.17	0.198	0.260	0.264	0.262
214.73	1.588	1.755	1.831	214.53	0.217	0.282	0.271	0.276
173.62	1.567	1.730	1.792	173.43	0.238	0.307	0.310	0.309
200.30	1.560	1.723	1.801	200.11	0.244	0.314	0.300	0.307
205.74	1.560	1.723	1.801	205.55	0.245	0.314	0.300	0.307
213.83	1.560	1.720	1.800	213.64	0.245	0.317	0.301	0.309
218.65	1.560	1.720	1.801	218.46	0.245	0.317	0.300	0.309
221.86	1.559	1.719	1.800	221.66	0.246	0.318	0.301	0.310
223.71	1.560	1.721	1.800	223.51	0.245	0.316	0.301	0.308

Table A.3 Initial and zeroed readings for control test 3 (continued)

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
225.25	1.560	1.721	1.800	225.05	0.245	0.316	0.301	0.308
226.58	1.559	1.723	1.800	226.38	0.246	0.314	0.302	0.308
229.13	1.558	1.723	1.800	228.94	0.246	0.314	0.301	0.307
191.23	1.542	1.703	1.780	191.04	0.263	0.334	0.321	0.327
155.74	1.521	1.682	1.758	155.55	0.284	0.355	0.344	0.350
179.36	1.502	1.661	1.738	179.17	0.303	0.376	0.364	0.370
166.08	1.482	1.637	1.715	165.89	0.323	0.400	0.386	0.393
167.74	1.462	1.616	1.692	167.55	0.343	0.421	0.410	0.415
242.17	1.444	1.594	1.672	241.98	0.361	0.443	0.430	0.437
230.57	1.427	1.573	1.652	230.38	0.377	0.464	0.449	0.456
222.06	1.411	1.556	1.634	221.87	0.394	0.481	0.467	0.474
171.75	1.393	1.534	1.617	171.56	0.411	0.503	0.484	0.494
195.06	1.392	1.534	1.616	194.87	0.413	0.503	0.485	0.494
195.70	1.391	1.534	1.614	195.51	0.414	0.503	0.488	0.495
201.57	1.391	1.533	1.614	201.37	0.414	0.504	0.487	0.496
205.85	1.392	1.533	1.614	205.66	0.413	0.504	0.487	0.496
208.38	1.391	1.530	1.614	208.19	0.413	0.507	0.487	0.497
210.61	1.391	1.529	1.614	210.42	0.413	0.508	0.487	0.498
212.79	1.391	1.530	1.614	212.60	0.414	0.507	0.487	0.497
214.41	1.391	1.530	1.614	214.22	0.414	0.507	0.487	0.497
262.92	1.390	1.529	1.614	262.72	0.414	0.508	0.487	0.497
211.59	1.371	1.507	1.592	211.39	0.434	0.530	0.509	0.519
197.28	1.352	1.488	1.571	197.09	0.453	0.549	0.530	0.539
198.14	1.334	1.468	1.552	197.94	0.471	0.569	0.549	0.559
199.36	1.317	1.448	1.533	199.17	0.488	0.589	0.569	0.579
226.62	1.302	1.429	1.517	226.43	0.503	0.608	0.584	0.596
235.33	1.285	1.412	1.498	235.14	0.520	0.625	0.603	0.614
252.58	1.268	1.392	1.481	252.39	0.537	0.645	0.620	0.632
256.06	1.251	1.373	1.462	255.86	0.554	0.664	0.639	0.651
274.97	1.235	1.350	1.442	274.78	0.570	0.687	0.659	0.673
225.93	1.226	1.342	1.431	225.74	0.579	0.695	0.670	0.683
240.67	1.226	1.340	1.430	240.48	0.579	0.697	0.671	0.684
241.67	1.225	1.341	1.431	241.48	0.580	0.696	0.670	0.683
244.27	1.225	1.341	1.431	244.08	0.580	0.696	0.670	0.683
246.26	1.225	1.341	1.431	246.07	0.580	0.696	0.670	0.683
248.11	1.226	1.341	1.431	247.92	0.579	0.696	0.671	0.684
249.47	1.225	1.341	1.431	249.27	0.579	0.696	0.670	0.683
250.67	1.225	1.340	1.431	250.48	0.580	0.697	0.671	0.684
256.22	1.225	1.341	1.431	256.03	0.580	0.696	0.670	0.683
235.06	1.207	1.316	1.411	234.87	0.598	0.721	0.690	0.706
247.16	1.188	1.297	1.389	246.97	0.617	0.740	0.713	0.726
284.25	1.169	1.257	1.368	284.05	0.636	0.780	0.733	0.756
264.37	1.151	1.253	1.347	264.18	0.654	0.784	0.754	0.769

Table A.3 Initial and zeroed readings for control test 3 (continued)

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
254.06	1.134	1.232	1.330	253.87	0.671	0.805	0.771	0.788
253.35	1.118	1.208	1.312	253.16	0.687	0.829	0.789	0.809
245.93	1.100	1.198	1.295	245.74	0.705	0.839	0.807	0.823
242.36	1.082	1.179	1.277	242.16	0.723	0.858	0.824	0.841
228.72	1.062	1.149	1.256	228.52	0.743	0.888	0.845	0.866
208.14	1.051	1.143	1.244	207.94	0.754	0.894	0.857	0.875
223.73	1.050	1.144	1.244	223.54	0.755	0.893	0.857	0.875
231.34	1.050	1.144	1.242	231.14	0.755	0.893	0.859	0.876
234.58	1.050	1.145	1.242	234.39	0.755	0.892	0.859	0.876
237.07	1.050	1.143	1.241	236.88	0.755	0.894	0.860	0.877
239.15	1.050	1.144	1.241	238.96	0.755	0.893	0.860	0.877
240.90	1.050	1.143	1.241	240.71	0.754	0.894	0.861	0.877
242.15	1.050	1.142	1.241	241.96	0.755	0.895	0.860	0.878
141.46	1.034	1.125	1.224	141.27	0.771	0.912	0.877	0.894
247.47	1.019	1.114	1.212	247.28	0.786	0.923	0.889	0.906
224.75	0.997	1.092	1.190	224.55	0.808	0.945	0.912	0.929
244.46	0.975	1.068	1.167	244.26	0.830	0.969	0.934	0.951
251.40	0.955	1.048	1.146	251.21	0.850	0.989	0.955	0.972
269.34	0.937	1.028	1.128	269.15	0.868	1.009	0.973	0.991
270.28	0.917	1.008	1.108	270.08	0.888	1.029	0.993	1.011
266.85	0.896	0.985	1.089	266.65	0.909	1.052	1.013	1.032
241.13	0.874	0.963	1.067	240.94	0.931	1.074	1.034	1.054
224.85	0.859	0.951	1.053	224.66	0.946	1.086	1.048	1.067
241.92	0.858	0.949	1.052	241.73	0.947	1.089	1.050	1.069
250.90	0.858	0.947	1.052	250.71	0.947	1.090	1.050	1.070
254.60	0.858	0.947	1.052	254.41	0.947	1.090	1.049	1.070
257.16	0.858	0.944	1.052	256.97	0.947	1.093	1.050	1.071
259.22	0.859	0.946	1.051	259.02	0.946	1.091	1.050	1.070
260.98	0.858	0.945	1.052	260.79	0.947	1.092	1.050	1.071
311.44	0.858	0.946	1.051	311.25	0.947	1.091	1.050	1.071
241.13	0.835	0.925	1.029	240.94	0.970	1.112	1.072	1.092
282.85	0.817	0.905	1.011	282.66	0.988	1.132	1.091	1.111
288.84	0.797	0.891	0.991	288.65	1.007	1.146	1.110	1.128
276.18	0.775	0.866	0.968	275.99	1.030	1.171	1.134	1.152
266.22	0.754	0.845	0.949	266.03	1.051	1.192	1.152	1.172
241.67	0.733	0.824	0.929	241.48	1.072	1.213	1.172	1.193
230.44	0.714	0.805	0.911	230.25	1.091	1.232	1.190	1.211
244.93	0.695	0.788	0.893	244.74	1.110	1.249	1.208	1.229
283.60	0.675	0.764	0.874	283.41	1.129	1.273	1.227	1.250
299.19	0.666	0.758	0.865	299.00	1.139	1.279	1.236	1.258
307.30	0.666	0.758	0.865	307.11	1.139	1.279	1.236	1.258
314.64	0.666	0.758	0.865	314.45	1.139	1.279	1.236	1.257
318.99	0.665	0.758	0.865	318.79	1.140	1.279	1.236	1.257

Table A.3 Initial and zeroed readings for control test 3 (continued)

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
320.07	0.666	0.758	0.866	319.88	1.139	1.279	1.236	1.257
320.36	0.666	0.758	0.865	320.17	1.139	1.279	1.236	1.258
320.63	0.665	0.758	0.865	320.44	1.140	1.279	1.236	1.258
325.93	0.665	0.757	0.865	325.74	1.140	1.280	1.237	1.258
274.04	0.664	0.753	0.864	273.85	1.140	1.284	1.238	1.261
279.47	0.642	0.726	0.845	279.27	1.163	1.311	1.257	1.284
297.10	0.624	0.713	0.827	296.90	1.181	1.324	1.275	1.299
303.56	0.603	0.696	0.808	303.37	1.202	1.341	1.294	1.317
279.15	0.580	0.674	0.788	278.96	1.225	1.363	1.313	1.338
252.92	0.557	0.653	0.765	252.72	1.247	1.384	1.336	1.360
228.84	0.535	0.633	0.744	228.65	1.270	1.404	1.357	1.380
219.38	0.512	0.613	0.723	219.19	1.293	1.424	1.379	1.401
214.58	0.488	0.590	0.701	214.39	1.317	1.447	1.401	1.424
236.87	0.461	0.570	0.681	236.67	1.344	1.467	1.420	1.444
247.51	0.454	0.563	0.676	247.32	1.351	1.474	1.425	1.450
262.23	0.454	0.560	0.676	262.04	1.351	1.477	1.425	1.451
271.40	0.454	0.559	0.676	271.21	1.351	1.478	1.425	1.452
277.49	0.454	0.559	0.676	277.30	1.350	1.478	1.425	1.452
280.19	0.454	0.559	0.676	280.00	1.351	1.478	1.425	1.451
281.77	0.454	0.559	0.676	281.58	1.351	1.478	1.425	1.452
282.83	0.454	0.559	0.676	282.64	1.350	1.478	1.426	1.452
177.30	0.436	0.547	0.660	177.11	1.369	1.490	1.441	1.466
303.81	0.421	0.531	0.646	303.62	1.384	1.506	1.456	1.481
302.04	0.396	0.508	0.622	301.85	1.409	1.529	1.479	1.504
308.32	0.371	0.484	0.599	308.13	1.434	1.553	1.503	1.528
301.98	0.346	0.461	0.578	301.79	1.459	1.576	1.523	1.550
306.28	0.325	0.441	0.557	306.09	1.480	1.596	1.544	1.570
295.18	0.303	0.421	0.539	294.99	1.502	1.616	1.562	1.589
275.29	0.282	0.402	0.518	275.09	1.523	1.635	1.583	1.609
248.38	0.258	0.374	0.498	248.19	1.547	1.663	1.603	1.633
218.55	0.239	0.346	0.483	218.36	1.566	1.691	1.618	1.655
237.47	0.239	0.363	0.483	237.28	1.566	1.674	1.618	1.646
245.31	0.239	0.362	0.483	245.12	1.566	1.675	1.618	1.647
250.75	0.239	0.362	0.483	250.56	1.566	1.675	1.619	1.647
255.64	0.239	0.362	0.482	255.45	1.566	1.675	1.619	1.647
259.59	0.239	0.360	0.483	259.40	1.566	1.677	1.618	1.648
262.38	0.239	0.361	0.483	262.18	1.566	1.676	1.618	1.647
264.27	0.239	0.362	0.483	264.08	1.566	1.675	1.619	1.647
148.93	0.220	0.347	0.467	148.73	1.584	1.690	1.634	1.662
254.73	0.201	0.329	0.451	254.53	1.604	1.708	1.650	1.679
261.29	0.176	0.308	0.437	261.10	1.629	1.729	1.664	1.697
278.84	0.150	0.287	0.414	278.65	1.655	1.750	1.687	1.719
283.66	0.125	0.264	0.384	283.47	1.680	1.773	1.717	1.745

Table A.3 Initial and zeroed readings for control test 3 (continued)

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
274.79	0.100	0.243	0.365	274.60	1.705	1.794	1.736	1.765
245.74	0.076	0.221	0.344	245.55	1.729	1.816	1.757	1.786
205.31	0.049	0.199	0.323	205.12	1.756	1.838	1.779	1.808
184.37	0.028	0.182	0.303	184.18	1.777	1.855	1.798	1.827
229.88	0.027	0.182	0.303	229.69	1.778	1.855	1.798	1.827
243.10	0.027	0.182	0.303	242.91	1.778	1.855	1.798	1.827
248.86	0.027	0.182	0.303	248.67	1.778	1.855	1.798	1.826
253.08	0.027	0.182	0.304	252.89	1.778	1.855	1.798	1.826
256.41	0.027	0.182	0.303	256.22	1.778	1.855	1.798	1.827
258.68	0.027	0.182	0.303	258.48	1.778	1.855	1.798	1.826
260.07	0.027	0.182	0.304	259.88	1.778	1.855	1.798	1.826
260.92	0.027	0.182	0.303	260.73	1.778	1.855	1.798	1.827
261.34	0.027	0.181	0.304	261.14	1.778	1.856	1.798	1.827
222.44	0.011	0.170	0.290	222.25	1.794	1.867	1.811	1.839
267.01	0.000	0.159	0.280	266.82	1.804	1.879	1.821	1.850
264.95	-0.017	0.147	0.268	264.76	1.822	1.890	1.833	1.862
245.74	-0.036	0.131	0.252	245.55	1.841	1.906	1.849	1.877
235.29	-0.055	0.116	0.238	235.09	1.859	1.921	1.863	1.892
226.87	-0.073	0.100	0.222	226.67	1.877	1.937	1.879	1.908
230.46	-0.090	0.088	0.212	230.27	1.895	1.949	1.889	1.919
242.98	-0.107	0.073	0.197	242.79	1.912	1.964	1.904	1.934
253.27	-0.126	0.057	0.181	253.08	1.931	1.980	1.920	1.950
255.12	-0.146	0.042	0.164	254.93	1.951	1.996	1.937	1.967
280.19	-0.167	0.025	0.147	280.00	1.972	2.012	1.954	1.983
291.23	-0.188	0.013	0.132	291.04	1.993	2.024	1.970	1.997
236.22	-0.211	0.012	0.112	236.03	2.016	2.025	1.989	2.007

Table A.4 Initial and zeroed readings for oil lubricant test 1

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
0.60	1.338	1.999	2.025	0.00	0.000	0.000	0.000	0.000
0.64	1.341	1.999	2.025	0.04	0.003	0.000	0.000	0.000
0.62	1.344	1.999	2.025	0.02	0.006	0.001	0.001	0.001
0.62	1.342	1.999	2.026	0.02	0.004	0.001	0.001	0.001
0.68	1.341	1.999	2.025	0.08	0.003	0.000	0.001	0.000
0.68	1.345	1.999	2.025	0.08	0.007	0.000	0.001	0.000
0.66	1.341	1.999	2.025	0.06	0.003	0.001	0.000	0.000
0.64	1.344	1.999	2.025	0.04	0.006	0.000	0.001	0.000
0.66	1.342	1.999	2.025	0.06	0.004	0.000	0.000	0.000
0.70	1.344	1.999	2.025	0.10	0.006	0.000	0.000	0.000
0.66	1.342	1.999	2.025	0.06	0.004	0.001	0.000	0.000
0.66	1.346	1.999	2.025	0.06	0.008	0.000	0.001	0.000
0.66	1.341	1.999	2.025	0.06	0.003	0.001	0.000	0.000
0.89	1.342	1.999	2.025	0.29	0.004	0.001	0.001	0.001
24.54	1.342	1.995	2.015	23.94	0.004	0.004	0.010	0.007
66.46	1.346	1.987	2.014	65.86	0.008	0.011	0.010	0.011
113.52	1.344	1.984	2.010	112.92	0.006	0.014	0.015	0.015
157.45	1.344	1.978	2.009	156.85	0.006	0.021	0.016	0.018
189.29	1.345	1.978	2.007	188.69	0.007	0.020	0.018	0.019
218.10	1.345	1.974	2.002	217.50	0.007	0.025	0.023	0.024
238.58	1.345	1.968	1.999	237.98	0.007	0.031	0.026	0.028
229.79	1.342	1.959	1.990	229.19	0.004	0.040	0.035	0.037
246.20	1.344	1.956	1.988	245.60	0.006	0.043	0.037	0.040
234.45	1.354	1.947	1.981	233.85	0.016	0.051	0.044	0.048
241.17	1.374	1.917	1.975	240.57	0.036	0.081	0.050	0.066
249.72	1.391	1.932	1.966	249.12	0.053	0.067	0.058	0.063
250.57	1.411	1.926	1.964	249.97	0.073	0.073	0.061	0.067
250.77	1.434	1.915	1.957	250.17	0.096	0.083	0.068	0.076
248.54	1.459	1.910	1.949	247.94	0.121	0.088	0.076	0.082
239.91	1.489	1.898	1.941	239.31	0.151	0.101	0.084	0.092
262.28	1.517	1.878	1.930	261.68	0.179	0.120	0.095	0.108
223.15	1.555	1.881	1.914	222.55	0.217	0.117	0.111	0.114
241.63	1.577	1.862	1.909	241.03	0.239	0.137	0.115	0.126
238.94	1.605	1.862	1.902	238.34	0.267	0.137	0.123	0.130
257.52	1.603	1.862	1.903	256.92	0.265	0.136	0.122	0.129
256.38	1.603	1.861	1.903	255.78	0.265	0.138	0.122	0.130
259.96	1.603	1.860	1.903	259.36	0.265	0.138	0.122	0.130
261.68	1.601	1.860	1.903	261.08	0.263	0.139	0.122	0.130
262.19	1.605	1.860	1.903	261.59	0.267	0.139	0.122	0.130
263.70	1.602	1.859	1.903	263.11	0.264	0.140	0.122	0.131
267.72	1.599	1.859	1.903	267.12	0.261	0.140	0.122	0.131
231.36	1.62	1.850	1.896	230.76	0.282	0.148	0.129	0.139
259.69	1.635	1.847	1.893	259.09	0.297	0.152	0.131	0.142

Table A.4 Initial and zeroed readings for oil lubricant test 1 (continued)

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
241.17	1.657	1.837	1.887	240.57	0.319	0.162	0.138	0.150
269.00	1.679	1.829	1.878	268.40	0.341	0.170	0.146	0.158
256.69	1.708	1.820	1.867	256.09	0.370	0.179	0.158	0.168
233.35	1.733	1.809	1.855	232.75	0.395	0.190	0.170	0.180
251.27	1.751	1.801	1.847	250.67	0.413	0.198	0.177	0.188
263.70	1.77	1.794	1.840	263.11	0.432	0.204	0.184	0.194
252.92	1.791	1.785	1.833	252.32	0.453	0.213	0.192	0.203
242.68	1.812	1.775	1.824	242.08	0.474	0.223	0.201	0.212
272.09	1.826	1.770	1.821	271.49	0.488	0.229	0.203	0.216
248.00	1.847	1.763	1.807	247.40	0.509	0.236	0.217	0.226
262.24	1.863	1.755	1.806	261.64	0.525	0.244	0.218	0.231
252.47	1.884	1.747	1.788	251.87	0.546	0.252	0.237	0.244
254.66	1.901	1.735	1.784	254.06	0.563	0.264	0.241	0.252
255.74	1.922	1.733	1.776	255.14	0.584	0.265	0.249	0.257
231.84	1.943	1.720	1.765	231.24	0.605	0.279	0.260	0.269
252.03	1.964	1.703	1.760	251.43	0.626	0.296	0.265	0.280
256.15	1.993	1.671	1.744	255.55	0.655	0.327	0.281	0.304
246.99	2.01	1.693	1.738	246.39	0.672	0.306	0.286	0.296
244.63	2.01	1.694	1.739	244.03	0.672	0.305	0.286	0.296
254.33	2.007	1.694	1.738	253.73	0.669	0.305	0.287	0.296
254.56	2.008	1.694	1.737	253.96	0.670	0.305	0.288	0.296
258.88	2.008	1.692	1.737	258.28	0.670	0.306	0.287	0.297
259.17	2.007	1.692	1.737	258.57	0.669	0.307	0.288	0.297
260.93	2.007	1.692	1.737	260.33	0.669	0.307	0.287	0.297
216.98	2.024	1.686	1.732	216.38	0.686	0.313	0.293	0.303
216.38	2.035	1.676	1.726	215.78	0.697	0.322	0.299	0.311
268.84	2.05	1.671	1.717	268.24	0.712	0.327	0.307	0.317
242.04	2.075	1.659	1.703	241.44	0.737	0.339	0.321	0.330
248.19	2.083	1.649	1.695	247.59	0.745	0.349	0.330	0.340
266.58	2.1	1.642	1.694	265.98	0.762	0.357	0.331	0.344
276.16	2.113	1.637	1.687	275.56	0.775	0.362	0.338	0.350
266.15	2.125	1.629	1.678	265.55	0.787	0.370	0.347	0.358
242.18	2.137	1.622	1.675	241.58	0.799	0.377	0.350	0.363
256.28	2.149	1.615	1.645	255.68	0.811	0.384	0.380	0.382
271.09	2.161	1.606	1.663	270.49	0.823	0.393	0.361	0.377
267.06	2.176	1.598	1.652	266.46	0.838	0.400	0.372	0.386
229.23	2.189	1.592	1.644	228.63	0.851	0.407	0.381	0.394
239.97	2.202	1.580	1.636	239.37	0.864	0.419	0.389	0.404
262.88	2.217	1.566	1.625	262.28	0.879	0.433	0.399	0.416
259.71	2.234	1.565	1.616	259.11	0.896	0.434	0.409	0.421
225.73	2.247	1.552	1.605	225.13	0.909	0.446	0.420	0.433
230.99	2.261	1.542	1.596	230.39	0.923	0.457	0.428	0.443
259.61	2.273	1.534	1.586	259.01	0.935	0.465	0.439	0.452

Table A.4 Initial and zeroed readings for oil lubricant test 1 (continued)

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
254.14	2.289	1.519	1.577	253.55	0.951	0.480	0.448	0.464
250.96	2.286	1.523	1.576	250.36	0.948	0.476	0.449	0.462
265.65	2.286	1.522	1.576	265.05	0.948	0.476	0.449	0.462
263.23	2.285	1.522	1.576	262.63	0.947	0.476	0.449	0.463
268.82	2.285	1.522	1.576	268.22	0.947	0.477	0.449	0.463
267.99	2.281	1.522	1.575	267.39	0.943	0.476	0.450	0.463
272.27	2.284	1.522	1.575	271.67	0.946	0.476	0.450	0.463
209.84	2.294	1.513	1.567	209.24	0.956	0.485	0.458	0.472
215.72	2.299	1.508	1.559	215.12	0.961	0.491	0.465	0.478
248.76	2.307	1.497	1.551	248.17	0.969	0.501	0.474	0.488
262.71	2.322	1.488	1.543	262.11	0.984	0.511	0.482	0.496
243.07	2.336	1.472	1.529	242.47	0.998	0.527	0.496	0.512
208.56	2.344	1.460	1.517	207.96	1.006	0.538	0.508	0.523
232.40	2.351	1.453	1.511	231.80	1.013	0.545	0.514	0.530
250.63	2.357	1.447	1.501	250.03	1.019	0.552	0.524	0.538
248.39	2.366	1.439	1.494	247.79	1.028	0.560	0.531	0.545
216.65	2.372	1.431	1.486	216.05	1.034	0.568	0.539	0.553
235.19	2.377	1.421	1.481	234.59	1.039	0.577	0.544	0.560
248.81	2.385	1.411	1.474	248.21	1.047	0.588	0.551	0.569
246.65	2.393	1.408	1.464	246.05	1.055	0.590	0.561	0.576
213.55	2.403	1.398	1.455	212.95	1.065	0.601	0.569	0.585
228.80	2.407	1.390	1.447	228.20	1.069	0.608	0.578	0.593
248.54	2.416	1.375	1.443	247.94	1.078	0.623	0.581	0.602
232.00	2.428	1.369	1.426	231.40	1.090	0.630	0.598	0.614
204.26	2.432	1.356	1.413	203.66	1.094	0.642	0.611	0.627
225.22	2.44	1.352	1.409	224.62	1.102	0.646	0.616	0.631
235.67	2.445	1.353	1.409	235.07	1.107	0.646	0.616	0.631
234.80	2.444	1.353	1.409	234.20	1.106	0.645	0.616	0.631
241.61	2.441	1.354	1.408	241.01	1.103	0.645	0.617	0.631
240.47	2.441	1.353	1.409	239.87	1.103	0.646	0.616	0.631
243.80	2.442	1.353	1.409	243.20	1.104	0.645	0.616	0.631
244.09	2.442	1.353	1.409	243.49	1.104	0.645	0.616	0.631
205.50	2.449	1.346	1.397	204.90	1.111	0.653	0.628	0.640
222.61	2.458	1.331	1.389	222.01	1.120	0.667	0.636	0.652
210.13	2.465	1.315	1.373	209.53	1.127	0.684	0.651	0.668
241.92	2.47	1.300	1.362	241.32	1.132	0.698	0.663	0.681
232.05	2.478	1.296	1.351	231.45	1.140	0.703	0.674	0.689
203.24	2.484	1.282	1.339	202.64	1.146	0.717	0.686	0.702
229.73	2.487	1.267	1.332	229.13	1.149	0.732	0.693	0.712
233.43	2.492	1.267	1.321	232.83	1.154	0.732	0.704	0.718
193.37	2.497	1.253	1.310	192.77	1.159	0.745	0.715	0.730
229.79	2.5	1.251	1.299	229.19	1.162	0.748	0.726	0.737
191.05	2.505	1.232	1.285	190.45	1.167	0.767	0.740	0.754

Table A.4 Initial and zeroed readings for oil lubricant test 1 (continued)

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
213.42	2.512	1.226	1.281	212.82	1.174	0.773	0.744	0.758
220.48	2.517	1.196	1.258	219.88	1.179	0.802	0.767	0.785
169.45	2.522	1.152	1.243	168.85	1.184	0.846	0.782	0.814
211.99	2.528	1.148	1.226	211.39	1.190	0.851	0.799	0.825
193.64	2.534	1.165	1.212	193.04	1.196	0.833	0.813	0.823
197.76	2.538	1.170	1.212	197.16	1.200	0.828	0.813	0.821
208.52	2.535	1.170	1.212	207.92	1.197	0.828	0.813	0.821
213.22	2.537	1.170	1.211	212.62	1.199	0.829	0.813	0.821
220.50	2.534	1.166	1.211	219.90	1.196	0.833	0.814	0.823
176.22	2.538	1.095	1.201	175.62	1.200	0.903	0.824	0.864
169.93	2.542	1.143	1.187	169.33	1.204	0.856	0.838	0.847
221.84	2.545	1.131	1.177	221.24	1.207	0.868	0.848	0.858
184.95	2.547	1.108	1.161	184.35	1.209	0.891	0.864	0.877
217.64	2.551	1.111	1.154	217.04	1.213	0.888	0.871	0.880
170.59	2.555	0.995	1.139	169.99	1.217	1.004	0.885	0.945
210.07	2.559	1.091	1.133	209.47	1.221	0.908	0.891	0.900
221.41	2.564	1.071	1.124	220.81	1.226	0.928	0.901	0.915
174.85	2.571	1.009	1.104	174.25	1.233	0.989	0.921	0.955
214.95	2.575	1.059	1.103	214.35	1.237	0.940	0.922	0.931
201.15	2.579	1.004	1.088	200.55	1.241	0.994	0.936	0.965
201.44	2.583	1.025	1.077	200.84	1.245	0.974	0.947	0.961
175.43	2.589	1.021	1.059	174.83	1.251	0.977	0.966	0.972
179.30	2.593	1.000	1.048	178.70	1.255	0.998	0.976	0.987
201.65	2.592	1.007	1.048	201.05	1.254	0.991	0.976	0.984
201.11	2.594	1.008	1.048	200.51	1.256	0.990	0.977	0.984
206.35	2.594	1.009	1.048	205.75	1.256	0.990	0.977	0.983
209.88	2.594	1.009	1.048	209.28	1.256	0.990	0.976	0.983
211.87	2.597	1.010	1.048	211.27	1.259	0.989	0.977	0.983
183.19	2.596	1.002	1.042	182.59	1.258	0.997	0.983	0.990
220.79	2.597	0.980	1.039	220.19	1.259	1.018	0.986	1.002
192.77	2.597	0.984	1.031	192.17	1.259	1.015	0.994	1.004
207.55	2.6	0.979	1.022	206.95	1.262	1.019	1.003	1.011
212.51	2.601	0.971	1.014	211.91	1.263	1.028	1.010	1.019
190.76	2.604	0.957	1.003	190.16	1.266	1.041	1.022	1.032
224.60	2.604	0.945	0.994	224.00	1.266	1.053	1.031	1.042
173.26	2.606	0.935	0.978	172.66	1.268	1.063	1.046	1.055
215.41	2.605	0.924	0.970	214.81	1.267	1.075	1.054	1.065
220.25	2.609	0.886	0.958	219.65	1.271	1.113	1.067	1.090
184.45	2.612	0.911	0.953	183.85	1.274	1.087	1.072	1.080
224.18	2.615	0.890	0.947	223.58	1.277	1.108	1.078	1.093
187.58	2.617	0.886	0.936	186.98	1.279	1.112	1.089	1.101
205.54	2.625	0.879	0.926	204.94	1.287	1.119	1.099	1.109
193.74	2.629	0.868	0.914	193.14	1.291	1.131	1.111	1.121

Table A.4 Initial and zeroed readings for oil lubricant test 1 (continued)

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
224.80	2.627	0.854	0.901	224.20	1.289	1.144	1.124	1.134
196.54	2.63	0.824	0.882	195.94	1.292	1.174	1.142	1.158
189.52	2.63	0.776	0.882	188.92	1.292	1.222	1.143	1.183
209.30	2.631	0.823	0.881	208.70	1.293	1.175	1.143	1.159
211.87	2.634	0.832	0.882	211.27	1.296	1.166	1.143	1.154
212.51	2.635	0.831	0.882	211.91	1.297	1.167	1.143	1.155
219.61	2.634	0.830	0.882	219.01	1.296	1.169	1.143	1.156
198.46	2.634	0.821	0.872	197.86	1.296	1.177	1.153	1.165
228.42	2.638	0.798	0.860	227.82	1.300	1.201	1.165	1.183
213.46	2.64	0.794	0.848	212.86	1.302	1.205	1.176	1.191
199.60	2.647	0.791	0.841	199.00	1.309	1.208	1.184	1.196
226.54	2.65	0.786	0.834	225.94	1.312	1.212	1.191	1.202
231.45	2.652	0.773	0.823	230.85	1.314	1.226	1.202	1.214
198.52	2.652	0.760	0.810	197.92	1.314	1.239	1.215	1.227
198.15	2.653	0.751	0.801	197.55	1.315	1.247	1.224	1.236
223.60	2.653	0.743	0.790	223.00	1.315	1.256	1.235	1.245
224.55	2.656	0.734	0.778	223.95	1.318	1.265	1.247	1.256
171.73	2.659	0.716	0.761	171.13	1.321	1.282	1.264	1.273
198.94	2.659	0.703	0.748	198.34	1.321	1.296	1.277	1.286
233.08	2.66	0.684	0.731	232.48	1.322	1.314	1.293	1.304
180.93	2.661	0.667	0.709	180.34	1.323	1.332	1.316	1.324

Table A.5 Initial and zeroed readings for oil lubricant test 2

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
0.52	1.227	1.926	2.048	0.00	0.000	0.000	0.000	0.000
0.66	1.232	1.927	2.048	0.14	0.005	0.001	0.000	0.001
0.58	1.229	1.927	2.048	0.06	0.002	0.001	0.000	0.000
0.60	1.229	1.927	2.048	0.08	0.002	0.001	0.000	0.000
0.66	1.230	1.927	2.048	0.14	0.003	0.001	0.000	0.000
0.58	1.230	1.927	2.048	0.06	0.003	0.001	0.000	0.000
0.91	1.230	1.927	2.048	0.40	0.003	0.001	0.000	0.000
0.80	1.229	1.926	2.048	0.29	0.002	0.000	0.000	0.000
0.78	1.229	1.927	2.048	0.27	0.002	0.001	0.000	0.000
0.65	1.231	1.927	2.048	0.14	0.004	0.001	0.000	0.000
0.69	1.227	1.927	2.048	0.18	0.000	0.000	0.000	0.000
0.75	1.230	1.927	2.048	0.23	0.003	0.001	0.000	0.000
0.77	1.230	1.927	2.049	0.25	0.003	0.001	0.001	0.001
0.70	1.229	1.927	2.048	0.19	0.002	0.001	0.000	0.000
0.52	1.229	1.927	2.048	0.00	0.002	0.000	0.000	0.000
32.30	1.230	1.926	2.041	31.78	0.003	0.001	0.008	0.004
118.51	1.230	1.907	2.035	117.99	0.003	0.019	0.013	0.016
170.92	1.231	1.915	2.014	170.40	0.004	0.011	0.034	0.023
207.67	1.231	1.900	2.005	207.15	0.004	0.027	0.043	0.035
214.27	1.257	1.897	2.011	213.75	0.030	0.030	0.037	0.033
200.78	1.290	1.888	2.003	200.26	0.063	0.039	0.045	0.042
211.95	1.289	1.888	2.003	211.44	0.062	0.038	0.046	0.042
213.50	1.290	1.888	2.003	212.99	0.063	0.039	0.045	0.042
214.68	1.290	1.888	2.003	214.17	0.063	0.039	0.045	0.042
215.41	1.289	1.888	2.002	214.89	0.062	0.039	0.046	0.042
215.95	1.289	1.887	2.003	215.43	0.062	0.039	0.045	0.042
216.28	1.289	1.885	2.002	215.76	0.062	0.042	0.046	0.044
201.73	1.312	1.872	1.995	201.21	0.085	0.054	0.053	0.054
163.45	1.360	1.862	1.975	162.93	0.133	0.065	0.073	0.069
148.16	1.408	1.847	1.960	147.64	0.181	0.079	0.088	0.083
150.89	1.452	1.831	1.946	150.37	0.225	0.095	0.102	0.099
203.63	1.482	1.819	1.936	203.12	0.255	0.107	0.112	0.110
178.14	1.513	1.809	1.913	177.62	0.286	0.118	0.135	0.126
157.01	1.553	1.794	1.910	156.50	0.326	0.132	0.138	0.135
190.29	1.577	1.784	1.898	189.77	0.350	0.143	0.151	0.147
140.71	1.618	1.767	1.886	140.19	0.391	0.159	0.162	0.161
193.08	1.647	1.755	1.871	192.56	0.420	0.172	0.177	0.174
123.86	1.698	1.737	1.849	123.35	0.471	0.190	0.199	0.195
180.91	1.725	1.716	1.839	180.40	0.498	0.211	0.210	0.210
151.32	1.749	1.714	1.833	150.81	0.522	0.212	0.215	0.214
159.70	1.748	1.714	1.826	159.19	0.521	0.212	0.222	0.217
164.77	1.748	1.714	1.827	164.26	0.521	0.212	0.221	0.217
167.55	1.748	1.714	1.827	167.03	0.521	0.212	0.221	0.217

Table A.5 Initial and zeroed readings for oil lubricant test 2 (continued)

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
170.53	1.748	1.713	1.829	170.01	0.521	0.213	0.219	0.216
172.29	1.750	1.713	1.829	171.77	0.523	0.213	0.219	0.216
201.88	1.749	1.700	1.828	201.36	0.522	0.226	0.220	0.223
181.04	1.777	1.689	1.812	180.52	0.550	0.237	0.236	0.237
167.26	1.803	1.689	1.802	166.74	0.576	0.238	0.246	0.242
125.21	1.833	1.674	1.781	124.69	0.606	0.252	0.267	0.259
163.18	1.852	1.656	1.779	162.66	0.625	0.270	0.269	0.270
172.60	1.871	1.650	1.766	172.08	0.644	0.276	0.283	0.279
146.19	1.894	1.640	1.746	145.68	0.667	0.287	0.302	0.295
143.34	1.918	1.632	1.743	142.82	0.691	0.294	0.306	0.300
175.45	1.931	1.626	1.737	174.93	0.704	0.300	0.311	0.306
174.46	1.948	1.617	1.721	173.94	0.721	0.309	0.327	0.318
135.43	1.973	1.601	1.711	134.92	0.746	0.325	0.337	0.331
163.64	1.995	1.592	1.702	163.12	0.768	0.334	0.346	0.340
162.10	2.016	1.573	1.686	161.59	0.789	0.354	0.362	0.358
143.23	2.052	1.553	1.622	142.72	0.825	0.373	0.426	0.399
133.01	2.081	1.537	1.621	132.49	0.854	0.389	0.427	0.408
131.83	2.087	1.534	1.640	131.31	0.860	0.392	0.409	0.400
141.97	2.089	1.534	1.640	141.45	0.862	0.392	0.408	0.400
146.63	2.089	1.534	1.640	146.11	0.862	0.393	0.408	0.400
149.98	2.086	1.533	1.640	149.46	0.859	0.393	0.408	0.400
152.67	2.087	1.533	1.640	152.15	0.860	0.393	0.408	0.400
187.33	2.087	1.533	1.640	186.81	0.860	0.393	0.408	0.401
153.21	2.110	1.514	1.616	152.69	0.883	0.412	0.432	0.422
102.78	2.135	1.496	1.598	102.26	0.908	0.430	0.450	0.440
171.25	2.147	1.483	1.590	170.73	0.920	0.443	0.458	0.451
162.89	2.161	1.468	1.573	162.37	0.934	0.458	0.475	0.466
123.39	2.175	1.458	1.561	122.87	0.948	0.468	0.487	0.478
170.98	2.184	1.446	1.552	170.46	0.957	0.480	0.497	0.488
167.65	2.196	1.430	1.536	167.13	0.969	0.496	0.512	0.504
141.27	2.211	1.412	1.521	140.75	0.984	0.514	0.527	0.521
181.25	2.220	1.403	1.507	180.73	0.993	0.523	0.541	0.532
138.33	2.237	1.386	1.489	137.81	1.010	0.541	0.559	0.550
170.07	2.247	1.367	1.472	169.55	1.020	0.559	0.576	0.567
151.01	2.251	1.361	1.466	150.50	1.024	0.565	0.582	0.574
158.73	2.251	1.361	1.466	158.21	1.024	0.565	0.582	0.574
163.99	2.251	1.361	1.465	163.47	1.024	0.565	0.583	0.574
168.33	2.247	1.361	1.466	167.82	1.020	0.565	0.582	0.574
171.75	2.247	1.360	1.465	171.23	1.020	0.566	0.583	0.574
208.81	2.248	1.353	1.463	208.29	1.021	0.573	0.585	0.579
172.04	2.256	1.346	1.451	171.52	1.029	0.581	0.597	0.589
162.83	2.266	1.333	1.439	162.31	1.039	0.594	0.609	0.601
122.17	2.277	1.317	1.423	121.65	1.050	0.609	0.625	0.617

Table A.5 Initial and zeroed readings for oil lubricant test 2 (continued)

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
184.82	2.280	1.306	1.412	184.31	1.053	0.620	0.636	0.628
134.07	2.288	1.292	1.396	133.55	1.061	0.635	0.652	0.643
167.73	2.297	1.269	1.384	167.22	1.070	0.657	0.664	0.661
129.99	2.303	1.245	1.371	129.47	1.076	0.682	0.677	0.680
147.79	2.312	1.237	1.357	147.27	1.085	0.689	0.691	0.690
162.75	2.318	1.214	1.343	162.23	1.091	0.712	0.705	0.709
142.88	2.332	1.222	1.323	142.36	1.105	0.705	0.725	0.715
139.28	2.342	1.187	1.304	138.76	1.115	0.740	0.744	0.742
159.97	2.343	1.190	1.296	159.46	1.116	0.736	0.752	0.744
169.04	2.348	1.163	1.296	168.52	1.121	0.764	0.752	0.758
175.91	2.347	1.182	1.297	175.39	1.120	0.745	0.751	0.748
179.47	2.347	1.169	1.296	178.95	1.120	0.758	0.752	0.755
183.07	2.346	1.186	1.296	182.55	1.119	0.740	0.752	0.746
74.14	2.352	1.172	1.280	73.62	1.125	0.755	0.768	0.762
126.00	2.358	1.151	1.263	125.48	1.131	0.775	0.785	0.780
188.51	2.366	1.021	1.251	187.99	1.139	0.905	0.797	0.851
146.73	2.369	1.124	1.235	146.21	1.142	0.802	0.813	0.808
177.71	2.378	1.113	1.219	177.19	1.151	0.813	0.829	0.821
142.49	2.382	1.101	1.204	141.97	1.155	0.826	0.844	0.835
160.37	2.386	1.066	1.193	159.85	1.159	0.860	0.855	0.858
168.52	2.383	1.044	1.183	168.00	1.156	0.882	0.865	0.874
160.47	2.394	1.060	1.166	159.95	1.167	0.866	0.882	0.874
121.24	2.403	1.043	1.145	120.72	1.176	0.883	0.903	0.893
147.47	2.407	1.021	1.127	146.96	1.180	0.906	0.921	0.913
149.65	2.409	1.022	1.125	149.13	1.182	0.905	0.923	0.914
157.84	2.409	1.019	1.124	157.33	1.182	0.907	0.924	0.915
161.59	2.413	1.019	1.124	161.07	1.186	0.908	0.924	0.916
168.06	2.411	1.019	1.123	167.55	1.184	0.908	0.925	0.916
95.00	2.417	1.009	1.101	94.48	1.190	0.917	0.947	0.932
157.28	2.419	0.991	1.105	156.77	1.192	0.936	0.943	0.939
149.07	2.426	0.987	1.092	148.55	1.199	0.939	0.956	0.948
124.26	2.429	0.971	1.080	123.74	1.202	0.956	0.968	0.962
139.80	2.432	0.958	1.067	139.28	1.205	0.968	0.981	0.975
167.53	2.434	0.937	1.056	167.01	1.207	0.989	0.992	0.990
157.76	2.439	0.940	1.024	157.24	1.212	0.986	1.025	1.005
131.19	2.443	0.923	1.034	130.67	1.216	1.003	1.014	1.008
127.13	2.444	0.919	1.022	126.62	1.217	1.007	1.026	1.017
162.83	2.446	0.907	1.010	162.31	1.219	1.019	1.038	1.028
138.54	2.451	0.888	0.994	138.02	1.224	1.038	1.054	1.046
119.60	2.452	0.843	0.976	119.09	1.225	1.083	1.072	1.078
120.41	2.453	0.854	0.958	119.89	1.226	1.072	1.090	1.081
136.11	2.456	0.854	0.954	135.60	1.229	1.073	1.094	1.083
140.29	2.454	0.849	0.955	139.78	1.227	1.078	1.093	1.085

Table A.5 Initial and zeroed readings for oil lubricant test 2 (continued)

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
144.14	2.457	0.849	0.954	143.63	1.230	1.077	1.094	1.086
154.30	2.457	0.849	0.954	153.79	1.230	1.077	1.094	1.086
82.98	2.462	0.836	0.936	82.46	1.235	1.090	1.113	1.101
104.56	2.458	0.819	0.923	104.04	1.231	1.107	1.125	1.116
141.87	2.466	0.807	0.911	141.35	1.239	1.119	1.137	1.128
157.90	2.468	0.763	0.898	157.39	1.241	1.164	1.151	1.157
130.69	2.469	0.783	0.886	130.18	1.242	1.143	1.162	1.153
111.82	2.472	0.767	0.871	111.31	1.245	1.160	1.177	1.168
138.54	2.473	0.756	0.860	138.02	1.246	1.170	1.188	1.179
157.43	2.474	0.744	0.849	156.91	1.247	1.182	1.199	1.191
147.60	2.479	0.732	0.837	147.08	1.252	1.194	1.211	1.203
128.15	2.478	0.717	0.825	127.63	1.251	1.209	1.223	1.216
161.28	2.478	0.706	0.817	160.76	1.251	1.220	1.231	1.226
127.98	2.478	0.686	0.795	127.47	1.251	1.241	1.253	1.247
128.81	2.483	0.683	0.791	128.29	1.256	1.243	1.257	1.250
142.47	2.483	0.683	0.790	141.95	1.256	1.243	1.258	1.250
149.03	2.482	0.684	0.790	148.51	1.255	1.243	1.258	1.250
151.37	2.483	0.683	0.790	150.85	1.256	1.243	1.258	1.250
163.41	2.483	0.682	0.790	162.89	1.256	1.244	1.258	1.251

Table A.6 Initial and zeroed readings for oil lubricant test 3

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
0.60	1.212	1.977	2.037	0.00	0.000	0.000	0.000	0.000
0.64	1.221	1.976	2.037	0.04	0.009	0.000	0.001	0.000
0.64	1.219	1.977	2.037	0.04	0.007	0.000	0.000	0.000
0.60	1.219	1.976	2.037	0.00	0.007	0.001	0.001	0.001
0.64	1.217	1.976	2.037	0.04	0.005	0.000	0.000	0.000
0.62	1.216	1.976	2.037	0.02	0.004	0.001	0.000	0.001
0.68	1.216	1.977	2.037	0.08	0.004	0.000	0.000	0.000
0.68	1.216	1.977	2.037	0.08	0.004	0.000	0.001	0.000
0.62	1.217	1.976	2.037	0.02	0.005	0.000	0.001	0.000
0.66	1.218	1.976	2.037	0.06	0.006	0.000	0.000	0.000
0.68	1.217	1.976	2.037	0.08	0.005	0.000	0.001	0.000
0.68	1.216	1.977	2.037	0.08	0.004	0.000	0.000	0.000
0.62	1.217	1.976	2.037	0.02	0.005	0.000	0.000	0.000
0.74	1.217	1.976	2.037	0.14	0.005	0.000	0.000	0.000
0.70	1.217	1.977	2.037	0.10	0.005	0.000	0.000	0.000
5.26	1.212	1.976	2.037	4.66	0.000	0.000	0.000	0.000
14.15	1.215	1.975	2.037	13.55	0.003	0.002	0.001	0.001
25.08	1.212	1.979	2.033	24.48	0.000	0.002	0.004	0.003
36.50	1.213	1.979	2.034	35.90	0.001	0.003	0.003	0.003
46.02	1.216	1.976	2.031	45.42	0.004	0.001	0.006	0.003
53.49	1.212	1.976	2.026	52.89	0.000	0.001	0.011	0.006
60.69	1.216	1.976	2.027	60.09	0.004	0.001	0.010	0.006
65.39	1.215	1.976	2.030	64.79	0.003	0.001	0.007	0.004
67.52	1.217	1.976	2.029	66.92	0.005	0.001	0.008	0.005
68.86	1.217	1.976	2.029	68.26	0.005	0.001	0.008	0.005
69.96	1.219	1.976	2.029	69.36	0.007	0.001	0.008	0.004
70.83	1.218	1.975	2.029	70.23	0.006	0.001	0.008	0.004
71.62	1.22	1.976	2.030	71.02	0.008	0.001	0.007	0.004
77.06	1.219	1.976	2.029	76.46	0.007	0.001	0.008	0.004
98.29	1.218	1.972	2.028	97.69	0.006	0.005	0.009	0.007
112.30	1.221	1.971	2.028	111.70	0.009	0.005	0.009	0.007
123.26	1.219	1.969	2.026	122.67	0.007	0.007	0.011	0.009
141.04	1.22	1.968	2.023	140.44	0.008	0.009	0.014	0.011
160.57	1.219	1.964	2.022	159.97	0.007	0.012	0.015	0.014
178.45	1.219	1.963	2.018	177.85	0.007	0.014	0.019	0.016
195.27	1.218	1.960	2.018	194.68	0.006	0.016	0.019	0.018
212.86	1.219	1.957	2.015	212.26	0.007	0.020	0.022	0.021
226.46	1.22	1.953	2.013	225.86	0.008	0.024	0.024	0.024
214.00	1.221	1.948	2.008	213.40	0.009	0.028	0.029	0.029
217.21	1.23	1.924	1.995	216.61	0.018	0.052	0.042	0.047
213.90	1.242	1.932	1.998	213.30	0.030	0.045	0.039	0.042
220.54	1.258	1.930	1.993	219.94	0.046	0.046	0.044	0.045
238.27	1.27	1.924	1.987	237.67	0.058	0.053	0.050	0.051

Table A.6 Initial and zeroed readings for oil lubricant test 3 (continued)

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
230.53	1.273	1.921	1.983	229.94	0.061	0.055	0.054	0.055
234.84	1.273	1.922	1.984	234.24	0.061	0.055	0.053	0.054
236.00	1.271	1.922	1.984	235.40	0.059	0.055	0.053	0.054
237.36	1.271	1.922	1.984	236.76	0.059	0.055	0.053	0.054
238.52	1.268	1.921	1.984	237.92	0.056	0.056	0.053	0.054
239.23	1.266	1.922	1.984	238.63	0.054	0.055	0.053	0.054
239.93	1.264	1.922	1.984	239.33	0.052	0.055	0.053	0.054
240.45	1.263	1.922	1.984	239.85	0.051	0.055	0.053	0.054
240.86	1.264	1.922	1.984	240.26	0.052	0.055	0.053	0.054
245.76	1.268	1.921	1.983	245.16	0.056	0.056	0.054	0.055
211.97	1.28	1.915	1.979	211.37	0.068	0.062	0.058	0.060
238.67	1.281	1.911	1.975	238.07	0.069	0.066	0.062	0.064
219.63	1.303	1.900	1.968	219.03	0.091	0.076	0.069	0.072
241.03	1.323	1.895	1.960	240.43	0.111	0.082	0.077	0.080
200.90	1.353	1.886	1.949	200.30	0.141	0.091	0.088	0.090
224.22	1.377	1.874	1.941	223.62	0.165	0.102	0.096	0.099
233.02	1.394	1.865	1.930	232.42	0.182	0.112	0.107	0.109
214.70	1.42	1.858	1.920	214.11	0.208	0.118	0.117	0.118
234.45	1.439	1.851	1.915	233.85	0.227	0.126	0.122	0.124
230.95	1.456	1.843	1.909	230.35	0.244	0.133	0.128	0.131
217.77	1.477	1.834	1.897	217.17	0.265	0.143	0.140	0.142
236.83	1.491	1.828	1.894	236.23	0.279	0.149	0.143	0.146
215.24	1.506	1.819	1.888	214.64	0.294	0.158	0.149	0.154
231.69	1.521	1.815	1.878	231.09	0.309	0.162	0.159	0.160
242.37	1.535	1.809	1.878	241.77	0.323	0.167	0.159	0.163
204.09	1.557	1.802	1.862	203.49	0.345	0.175	0.175	0.175
244.65	1.572	1.794	1.864	244.05	0.360	0.183	0.173	0.178
205.12	1.593	1.783	1.845	204.52	0.381	0.193	0.192	0.193
234.86	1.612	1.776	1.841	234.26	0.400	0.200	0.196	0.198
223.06	1.632	1.767	1.836	222.47	0.420	0.210	0.201	0.205
217.33	1.656	1.756	1.824	216.73	0.444	0.221	0.213	0.217
200.12	1.669	1.752	1.821	199.52	0.457	0.224	0.216	0.220
208.68	1.668	1.752	1.821	208.08	0.456	0.225	0.216	0.220
214.83	1.668	1.752	1.821	214.23	0.456	0.225	0.216	0.220
220.25	1.666	1.752	1.821	219.65	0.454	0.225	0.216	0.220
222.51	1.665	1.752	1.821	221.91	0.453	0.224	0.216	0.220
224.02	1.664	1.752	1.821	223.42	0.452	0.224	0.216	0.220
225.44	1.663	1.752	1.822	224.84	0.451	0.225	0.215	0.220
226.46	1.661	1.752	1.821	225.86	0.449	0.225	0.216	0.220
164.07	1.689	1.742	1.809	163.47	0.477	0.234	0.228	0.231
212.35	1.706	1.733	1.801	211.75	0.494	0.244	0.236	0.240
245.91	1.728	1.710	1.789	245.31	0.516	0.267	0.248	0.257
203.22	1.757	1.706	1.778	202.62	0.545	0.270	0.258	0.264

Table A.6 Initial and zeroed readings for oil lubricant test 3 (continued)

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
240.16	1.774	1.702	1.768	239.56	0.562	0.275	0.269	0.272
205.97	1.801	1.690	1.760	205.37	0.589	0.286	0.277	0.282
238.19	1.817	1.680	1.755	237.59	0.605	0.297	0.282	0.289
205.23	1.84	1.669	1.743	204.63	0.628	0.307	0.294	0.301
243.01	1.85	1.667	1.738	242.41	0.638	0.309	0.299	0.304
207.38	1.865	1.659	1.729	206.78	0.653	0.318	0.308	0.313
243.88	1.876	1.653	1.725	243.28	0.664	0.323	0.312	0.317
215.49	1.892	1.646	1.708	214.89	0.680	0.331	0.329	0.330
231.18	1.907	1.639	1.709	230.58	0.695	0.337	0.328	0.332
222.67	1.92	1.632	1.706	222.07	0.708	0.345	0.331	0.338
223.75	1.939	1.627	1.697	223.15	0.727	0.350	0.340	0.345
234.53	1.95	1.618	1.687	233.93	0.738	0.358	0.350	0.354
194.82	1.974	1.606	1.679	194.22	0.762	0.371	0.358	0.365
233.27	1.988	1.599	1.668	232.67	0.776	0.378	0.369	0.374
213.73	2.006	1.592	1.661	213.13	0.794	0.385	0.376	0.380
221.04	2.009	1.592	1.657	220.44	0.797	0.385	0.380	0.382
223.75	2.008	1.592	1.657	223.15	0.796	0.385	0.380	0.382
227.14	2.009	1.592	1.657	226.54	0.797	0.385	0.380	0.382
229.64	2.004	1.592	1.657	229.05	0.792	0.385	0.380	0.382
231.57	2.007	1.592	1.657	230.97	0.795	0.385	0.380	0.382
161.90	2.019	1.578	1.639	161.30	0.807	0.398	0.398	0.398
214.02	2.038	1.573	1.635	213.42	0.826	0.404	0.402	0.403
180.65	2.065	1.561	1.626	180.05	0.853	0.416	0.411	0.414
229.89	2.079	1.549	1.616	229.29	0.867	0.427	0.421	0.424
176.11	2.106	1.538	1.604	175.51	0.894	0.439	0.433	0.436
235.77	2.116	1.529	1.596	235.17	0.904	0.447	0.441	0.444
187.18	2.136	1.518	1.578	186.58	0.924	0.458	0.459	0.459
221.57	2.151	1.511	1.573	220.98	0.939	0.465	0.464	0.465
180.67	2.163	1.499	1.567	180.07	0.951	0.477	0.470	0.474
225.32	2.176	1.491	1.559	224.72	0.964	0.485	0.478	0.482
211.31	2.182	1.484	1.551	210.71	0.970	0.493	0.486	0.489
212.74	2.199	1.472	1.540	212.14	0.987	0.504	0.497	0.501
216.59	2.205	1.465	1.532	215.99	0.993	0.511	0.505	0.508
219.34	2.223	1.453	1.523	218.74	1.011	0.524	0.514	0.519
232.00	2.232	1.446	1.513	231.40	1.020	0.531	0.524	0.528
209.30	2.233	1.441	1.511	208.70	1.021	0.536	0.526	0.531
221.49	2.234	1.442	1.509	220.89	1.022	0.534	0.528	0.531
225.63	2.234	1.442	1.509	225.03	1.022	0.534	0.528	0.531
229.25	2.234	1.442	1.510	228.65	1.022	0.534	0.527	0.531
231.30	2.233	1.442	1.509	230.70	1.021	0.534	0.528	0.531
232.40	2.232	1.442	1.509	231.80	1.020	0.535	0.528	0.531
236.12	2.233	1.443	1.510	235.52	1.021	0.534	0.527	0.531
206.12	2.244	1.435	1.498	205.52	1.032	0.542	0.539	0.541

Table A.6 Initial and zeroed readings for oil lubricant test 3 (continued)

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
225.05	2.251	1.421	1.494	224.45	1.039	0.556	0.543	0.549
229.46	2.26	1.419	1.485	228.86	1.048	0.558	0.552	0.555
180.48	2.274	1.406	1.470	179.88	1.062	0.571	0.567	0.569
240.34	2.283	1.397	1.463	239.74	1.071	0.580	0.574	0.577
192.79	2.294	1.385	1.451	192.19	1.082	0.592	0.586	0.589
240.78	2.302	1.375	1.439	240.18	1.090	0.601	0.598	0.599
203.92	2.314	1.361	1.429	203.32	1.102	0.615	0.608	0.612
241.17	2.317	1.359	1.419	240.57	1.105	0.617	0.618	0.617
197.55	2.325	1.345	1.412	196.95	1.113	0.631	0.625	0.628
232.87	2.334	1.338	1.404	232.27	1.122	0.638	0.633	0.636
215.41	2.337	1.330	1.396	214.81	1.125	0.647	0.641	0.644
198.52	2.344	1.316	1.385	197.92	1.132	0.661	0.652	0.656
241.79	2.351	1.316	1.377	241.19	1.139	0.661	0.660	0.660
199.70	2.356	1.303	1.366	199.10	1.144	0.673	0.671	0.672
206.45	2.362	1.296	1.357	205.85	1.150	0.681	0.680	0.681
223.09	2.361	1.296	1.356	222.49	1.149	0.681	0.681	0.681
221.84	2.363	1.296	1.356	221.24	1.151	0.681	0.681	0.681
226.91	2.364	1.296	1.355	226.31	1.152	0.681	0.682	0.681
229.93	2.363	1.295	1.356	229.34	1.151	0.682	0.681	0.681
231.05	2.365	1.295	1.355	230.45	1.153	0.682	0.682	0.682
232.65	2.365	1.294	1.355	232.05	1.153	0.683	0.682	0.682
233.70	2.362	1.294	1.356	233.10	1.150	0.683	0.681	0.682
236.29	2.363	1.294	1.356	235.69	1.151	0.683	0.681	0.682
190.43	2.371	1.281	1.346	189.83	1.159	0.696	0.691	0.693
234.74	2.373	1.275	1.340	234.14	1.161	0.701	0.697	0.699
195.67	2.382	1.256	1.329	195.07	1.170	0.721	0.708	0.715
204.09	2.388	1.164	1.317	203.49	1.176	0.813	0.720	0.767
225.44	2.392	1.240	1.306	224.84	1.180	0.736	0.731	0.734
183.71	2.402	1.229	1.291	183.11	1.190	0.748	0.746	0.747
235.58	2.406	1.223	1.283	234.98	1.194	0.754	0.754	0.754
185.90	2.413	1.205	1.271	185.30	1.201	0.771	0.766	0.769
230.35	2.416	1.198	1.262	229.75	1.204	0.778	0.775	0.776
211.81	2.42	1.161	1.252	211.21	1.208	0.815	0.785	0.800
190.78	2.426	1.178	1.240	190.18	1.214	0.799	0.797	0.798
228.34	2.43	1.099	1.231	227.74	1.218	0.878	0.806	0.842
194.49	2.436	1.089	1.219	193.89	1.224	0.888	0.818	0.853
191.53	2.442	1.151	1.207	190.93	1.230	0.826	0.830	0.828
224.29	2.446	1.120	1.202	223.69	1.234	0.857	0.835	0.846
163.49	2.449	1.131	1.185	162.89	1.237	0.845	0.852	0.849
181.95	2.451	1.117	1.176	181.35	1.239	0.860	0.861	0.860
189.71	2.456	1.115	1.175	189.11	1.244	0.862	0.862	0.862
200.18	2.456	1.111	1.174	199.58	1.244	0.865	0.863	0.864
200.45	2.456	1.113	1.174	199.85	1.244	0.863	0.863	0.863

Table A.6 Initial and zeroed readings for oil lubricant test 3 (continued)

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
204.71	2.46	1.112	1.175	204.11	1.248	0.864	0.862	0.863
206.72	2.457	1.111	1.174	206.12	1.245	0.865	0.863	0.864
208.06	2.463	1.113	1.174	207.46	1.251	0.863	0.863	0.863
142.78	2.464	1.107	1.163	142.18	1.252	0.869	0.874	0.872
207.75	2.466	1.100	1.156	207.15	1.254	0.877	0.881	0.879
172.24	2.473	1.084	1.140	171.64	1.261	0.893	0.897	0.895
231.42	2.477	1.074	1.131	230.82	1.265	0.902	0.906	0.904
172.37	2.48	1.058	1.115	171.77	1.268	0.918	0.922	0.920
215.26	2.487	1.029	1.105	214.66	1.275	0.947	0.932	0.940
169.66	2.49	1.035	1.095	169.06	1.278	0.942	0.942	0.942
208.00	2.496	1.027	1.086	207.40	1.284	0.949	0.951	0.950
218.55	2.498	1.021	1.078	217.95	1.286	0.956	0.959	0.957
177.79	2.499	1.003	1.067	177.19	1.287	0.974	0.970	0.972
214.56	2.501	1.002	1.060	213.96	1.289	0.974	0.977	0.976
191.80	2.504	0.983	1.048	191.20	1.292	0.994	0.989	0.991
198.11	2.508	0.982	1.038	197.51	1.296	0.995	0.999	0.997
221.31	2.509	0.973	1.029	220.71	1.297	1.003	1.008	1.006
193.87	2.517	0.960	1.015	193.27	1.305	1.016	1.022	1.019
208.41	2.519	0.934	1.004	207.81	1.307	1.042	1.033	1.038
190.20	2.52	0.919	0.999	189.61	1.308	1.058	1.038	1.048
206.12	2.52	0.940	0.999	205.52	1.308	1.036	1.038	1.037
207.69	2.52	0.941	0.999	207.09	1.308	1.036	1.038	1.037
211.50	2.519	0.942	0.999	210.90	1.307	1.035	1.038	1.036
213.38	2.52	0.943	0.999	212.78	1.308	1.034	1.038	1.036
261.66	2.524	0.941	0.999	261.06	1.312	1.035	1.038	1.036
222.82	2.528	0.923	0.979	222.22	1.316	1.053	1.058	1.056
200.05	2.532	0.917	0.969	199.46	1.320	1.060	1.068	1.064
219.28	2.532	0.895	0.954	218.68	1.320	1.082	1.083	1.082
192.25	2.535	0.874	0.939	191.65	1.323	1.103	1.098	1.100
198.01	2.537	0.834	0.928	197.41	1.325	1.142	1.109	1.126
225.47	2.538	0.865	0.917	224.87	1.326	1.112	1.120	1.116
222.57	2.538	0.854	0.908	221.97	1.326	1.122	1.129	1.125
191.61	2.538	0.843	0.898	191.01	1.326	1.134	1.139	1.137
219.92	2.537	0.820	0.890	219.32	1.325	1.156	1.147	1.152
225.82	2.54	0.827	0.881	225.22	1.328	1.150	1.156	1.153
190.20	2.542	0.812	0.870	189.61	1.330	1.164	1.167	1.165
230.97	2.544	0.802	0.859	230.37	1.332	1.174	1.178	1.176
224.76	2.548	0.792	0.847	224.16	1.336	1.185	1.190	1.188
213.88	2.55	0.791	0.841	213.28	1.338	1.186	1.196	1.191
218.45	2.549	0.789	0.841	217.85	1.337	1.187	1.196	1.192
225.07	2.55	0.790	0.841	224.47	1.338	1.186	1.196	1.191
226.27	2.548	0.790	0.841	225.67	1.336	1.187	1.196	1.191
229.69	2.55	0.788	0.840	229.09	1.338	1.189	1.197	1.193

Table A.6 Initial and zeroed readings for oil lubricant test 3 (continued)

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
231.34	2.551	0.788	0.840	230.74	1.339	1.189	1.197	1.193
231.49	2.55	0.785	0.836	230.89	1.338	1.192	1.201	1.196
217.27	2.556	0.774	0.826	216.67	1.344	1.203	1.211	1.207
204.83	2.556	0.763	0.818	204.23	1.344	1.214	1.219	1.216
213.30	2.566	0.752	0.807	212.70	1.354	1.224	1.230	1.227
225.26	2.564	0.740	0.795	224.66	1.352	1.237	1.242	1.240
184.60	2.568	0.725	0.781	184.00	1.356	1.252	1.256	1.254
204.81	2.569	0.713	0.770	204.21	1.357	1.263	1.267	1.265
224.82	2.569	0.703	0.760	224.22	1.357	1.273	1.277	1.275
234.98	2.57	0.690	0.748	234.38	1.358	1.287	1.289	1.288
221.47	2.574	0.679	0.736	220.87	1.362	1.298	1.301	1.300
176.22	2.577	0.665	0.721	175.62	1.365	1.311	1.316	1.314
184.08	2.578	0.654	0.709	183.48	1.366	1.323	1.328	1.325
211.75	2.58	0.641	0.697	211.15	1.368	1.336	1.340	1.338
217.54	2.582	0.628	0.682	216.94	1.370	1.348	1.355	1.351
198.63	2.585	0.622	0.676	198.03	1.373	1.355	1.361	1.358
199.50	2.585	0.622	0.676	198.90	1.373	1.354	1.361	1.358

Table A.7 Initial and zeroed readings for teflon pad test 1

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
0.19	1.644	1.974	2.054	0.00	0.000	0.000	0.000	0.000
0.62	1.644	1.974	2.054	0.44	0.000	0.000	0.000	0.000
0.24	1.644	1.974	2.053	0.05	0.000	0.000	0.001	0.001
0.50	1.644	1.974	2.053	0.31	0.000	0.000	0.001	0.000
0.55	1.645	1.975	2.054	0.37	0.000	0.000	0.000	0.000
0.56	1.644	1.975	2.053	0.37	0.000	0.000	0.001	0.001
0.22	1.644	1.975	2.053	0.04	0.000	0.000	0.001	0.000
0.33	1.644	1.974	2.053	0.14	0.000	0.000	0.001	0.000
0.67	1.644	1.974	2.053	0.48	0.001	0.000	0.001	0.000
11.90	1.644	1.975	2.053	9.95	0.001	0.001	0.001	0.001
49.82	1.644	1.974	2.053	49.63	0.001	0.000	0.001	0.000
97.68	1.643	1.975	2.030	97.49	0.001	0.000	0.023	0.012
127.99	1.638	1.958	2.040	127.80	0.006	0.016	0.013	0.015
137.24	1.632	1.959	2.027	137.06	0.012	0.016	0.026	0.021
152.90	1.627	1.944	2.014	152.71	0.017	0.030	0.039	0.035
191.69	1.620	1.936	1.999	191.50	0.025	0.038	0.055	0.046
223.62	1.609	1.928	1.982	223.44	0.035	0.046	0.072	0.059
229.99	1.595	1.911	1.962	229.80	0.049	0.063	0.092	0.078
227.24	1.579	1.896	1.948	227.05	0.065	0.078	0.106	0.092
228.03	1.562	1.882	1.928	227.84	0.083	0.093	0.126	0.109
188.01	1.551	1.868	1.917	187.82	0.094	0.106	0.137	0.122
175.83	1.547	1.869	1.917	175.64	0.098	0.105	0.137	0.121
163.06	1.544	1.868	1.912	162.88	0.100	0.106	0.141	0.124
154.75	1.543	1.865	1.912	154.56	0.102	0.109	0.141	0.125
149.88	1.541	1.866	1.913	149.70	0.103	0.109	0.141	0.125
146.10	1.540	1.865	1.914	145.91	0.104	0.109	0.140	0.125
142.90	1.540	1.865	1.912	142.71	0.105	0.109	0.142	0.126
140.44	1.539	1.865	1.906	140.26	0.105	0.110	0.147	0.129
164.14	1.537	1.851	1.904	163.96	0.107	0.123	0.150	0.137
227.55	1.530	1.848	1.893	227.37	0.115	0.126	0.161	0.143
225.41	1.514	1.829	1.872	225.23	0.130	0.145	0.181	0.163
223.37	1.497	1.810	1.841	223.19	0.148	0.164	0.213	0.188
227.18	1.480	1.793	1.836	226.99	0.165	0.182	0.218	0.200
228.41	1.464	1.776	1.816	228.22	0.181	0.199	0.238	0.218
226.64	1.448	1.759	1.797	226.45	0.196	0.216	0.257	0.236
225.43	1.432	1.737	1.778	225.25	0.212	0.237	0.276	0.256
228.11	1.417	1.721	1.761	227.93	0.227	0.254	0.293	0.273
229.36	1.402	1.705	1.743	229.18	0.243	0.269	0.310	0.290
195.97	1.390	1.697	1.730	195.79	0.254	0.278	0.323	0.301
180.42	1.386	1.697	1.731	180.24	0.258	0.277	0.322	0.300
168.90	1.384	1.696	1.731	168.72	0.261	0.278	0.323	0.301
161.65	1.383	1.694	1.727	161.46	0.262	0.280	0.327	0.303
156.68	1.381	1.694	1.728	156.49	0.263	0.281	0.326	0.303

Table A.7 Initial and zeroed readings for teflon pad test 1 (continued)

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
152.92	1.381	1.693	1.727	152.73	0.263	0.281	0.327	0.304
149.92	1.380	1.694	1.727	149.74	0.265	0.281	0.327	0.304
147.66	1.379	1.694	1.727	147.47	0.265	0.280	0.326	0.303
146.14	1.378	1.694	1.727	145.95	0.266	0.280	0.327	0.304
214.52	1.373	1.682	1.714	214.33	0.271	0.293	0.339	0.316
240.67	1.360	1.667	1.695	240.49	0.284	0.308	0.358	0.333
238.45	1.344	1.647	1.675	238.26	0.301	0.327	0.379	0.353
238.68	1.327	1.628	1.655	238.49	0.318	0.346	0.399	0.373
240.40	1.311	1.613	1.640	240.21	0.333	0.362	0.414	0.388
245.31	1.296	1.596	1.622	245.12	0.349	0.378	0.432	0.405
248.88	1.278	1.577	1.603	248.70	0.366	0.397	0.451	0.424
245.33	1.260	1.556	1.583	245.14	0.384	0.419	0.471	0.445
241.05	1.244	1.537	1.564	240.86	0.401	0.437	0.490	0.464
199.96	1.234	1.530	1.557	199.78	0.411	0.445	0.497	0.471
188.09	1.231	1.530	1.557	187.91	0.414	0.444	0.497	0.471
180.71	1.228	1.530	1.555	180.53	0.416	0.445	0.499	0.472
175.00	1.228	1.527	1.552	174.81	0.417	0.447	0.502	0.474
170.44	1.227	1.526	1.552	170.26	0.417	0.448	0.501	0.475
166.83	1.226	1.526	1.552	166.64	0.419	0.449	0.502	0.475
163.91	1.226	1.526	1.552	163.73	0.419	0.448	0.502	0.475
161.40	1.225	1.526	1.552	161.21	0.419	0.448	0.502	0.475
159.76	1.225	1.527	1.552	159.57	0.420	0.448	0.502	0.475
232.27	1.219	1.516	1.541	232.09	0.425	0.459	0.513	0.486
248.80	1.205	1.499	1.521	248.61	0.439	0.475	0.532	0.504
247.53	1.187	1.480	1.502	247.35	0.457	0.494	0.552	0.523
249.20	1.169	1.459	1.479	249.01	0.476	0.516	0.575	0.545
248.78	1.149	1.438	1.458	248.59	0.495	0.536	0.596	0.566
250.65	1.131	1.420	1.438	250.46	0.514	0.554	0.615	0.585
252.40	1.112	1.400	1.419	252.21	0.533	0.574	0.634	0.604
251.69	1.093	1.382	1.397	251.50	0.551	0.593	0.657	0.625
244.27	1.075	1.361	1.378	244.08	0.569	0.613	0.676	0.645
211.36	1.068	1.356	1.373	211.17	0.577	0.618	0.681	0.649
195.72	1.065	1.353	1.372	195.54	0.580	0.622	0.682	0.652
188.41	1.063	1.353	1.371	188.22	0.582	0.621	0.682	0.652
183.52	1.061	1.352	1.370	183.33	0.584	0.622	0.684	0.653
179.90	1.052	1.352	1.370	179.72	0.592	0.623	0.684	0.653
176.91	1.023	1.350	1.370	176.72	0.622	0.625	0.684	0.654
174.48	0.996	1.350	1.369	174.29	0.648	0.625	0.685	0.655
173.75	0.986	1.349	1.369	173.56	0.659	0.625	0.685	0.655
237.91	0.979	1.338	1.354	237.72	0.666	0.637	0.700	0.668
262.79	0.962	1.319	1.335	262.61	0.682	0.656	0.719	0.687
266.28	0.941	1.297	1.312	266.10	0.704	0.677	0.742	0.710
263.71	0.918	1.268	1.289	263.52	0.727	0.707	0.765	0.736

Table A.7 Initial and zeroed readings for teflon pad test 1 (continued)

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
262.50	0.895	1.249	1.264	262.31	0.749	0.725	0.789	0.757
262.50	0.874	1.203	1.244	262.31	0.770	0.771	0.810	0.791
261.52	0.853	1.204	1.220	261.34	0.792	0.770	0.833	0.802
262.90	0.832	1.098	1.200	262.71	0.813	0.877	0.854	0.865
239.07	0.815	1.158	1.186	238.88	0.830	0.816	0.868	0.842
214.83	0.810	1.161	1.183	214.64	0.835	0.813	0.871	0.842
205.16	0.808	1.167	1.182	204.98	0.837	0.807	0.872	0.839
199.55	0.806	1.167	1.181	199.36	0.838	0.807	0.872	0.840
195.52	0.805	1.164	1.182	195.33	0.839	0.810	0.872	0.841
192.36	0.805	1.151	1.182	192.17	0.840	0.823	0.872	0.848
189.69	0.804	1.159	1.180	189.51	0.840	0.815	0.874	0.845
187.37	0.803	1.162	1.180	187.18	0.841	0.812	0.874	0.843
202.52	0.803	1.162	1.179	202.34	0.842	0.812	0.875	0.844
253.98	0.792	1.146	1.162	253.79	0.852	0.829	0.892	0.860
270.11	0.768	1.118	1.135	269.92	0.877	0.856	0.919	0.888
268.34	0.747	1.010	1.115	268.16	0.898	0.964	0.938	0.951
264.39	0.727	0.986	1.094	264.21	0.918	0.988	0.960	0.974
263.06	0.707	1.062	1.077	262.88	0.937	0.912	0.977	0.945
262.31	0.689	1.046	1.060	262.13	0.955	0.928	0.993	0.961
261.73	0.671	1.029	1.041	261.55	0.973	0.945	1.012	0.979
260.17	0.654	1.009	1.025	259.99	0.990	0.965	1.029	0.997
261.86	0.638	0.997	1.007	261.67	1.007	0.977	1.047	1.012
236.68	0.621	0.982	0.991	236.49	1.023	0.992	1.063	1.028
219.67	0.616	0.981	0.990	219.49	1.028	0.994	1.063	1.028
211.32	0.614	0.973	0.991	211.13	1.030	1.001	1.063	1.032
205.54	0.612	0.977	0.991	205.35	1.032	0.997	1.063	1.030
201.30	0.611	0.976	0.988	201.11	1.033	0.999	1.065	1.032
198.01	0.611	0.977	0.987	197.82	1.034	0.998	1.066	1.032
195.14	0.610	0.975	0.987	194.96	1.034	0.999	1.066	1.033
192.79	0.609	0.964	0.987	192.61	1.035	1.011	1.067	1.039
190.73	0.609	0.968	0.987	190.55	1.036	1.007	1.067	1.037
234.89	0.605	0.965	0.977	234.71	1.040	1.010	1.076	1.043
273.06	0.596	0.958	0.965	272.88	1.048	1.017	1.088	1.053
273.15	0.576	0.937	0.944	272.96	1.068	1.037	1.109	1.073
272.85	0.555	0.915	0.924	272.67	1.089	1.059	1.130	1.094
268.82	0.533	0.871	0.903	268.63	1.111	1.103	1.151	1.127
264.79	0.510	0.876	0.880	264.60	1.135	1.098	1.173	1.136
263.77	0.487	0.844	0.860	263.58	1.157	1.130	1.194	1.162
261.59	0.465	0.833	0.840	261.40	1.180	1.141	1.214	1.178
260.42	0.443	0.816	0.821	260.24	1.201	1.158	1.233	1.196
254.91	0.423	0.796	0.803	254.73	1.221	1.178	1.250	1.214
224.02	0.416	0.793	0.801	223.83	1.229	1.182	1.253	1.217
213.12	0.414	0.789	0.799	212.94	1.231	1.185	1.255	1.220

Table A.7 Initial and zeroed readings for teflon pad test 1 (continued)

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
207.22	0.412	0.789	0.798	207.03	1.233	1.185	1.256	1.221
202.96	0.411	0.789	0.798	202.77	1.234	1.186	1.256	1.221
199.76	0.410	0.789	0.797	199.57	1.235	1.186	1.257	1.221
197.10	0.409	0.789	0.796	196.91	1.235	1.186	1.257	1.221
194.89	0.409	0.785	0.796	194.71	1.236	1.190	1.257	1.224
195.95	0.408	0.784	0.796	195.77	1.237	1.191	1.258	1.224
254.68	0.398	0.774	0.781	254.50	1.246	1.201	1.273	1.237
260.23	0.381	0.758	0.765	260.05	1.263	1.216	1.289	1.252
260.82	0.359	0.737	0.746	260.63	1.285	1.237	1.308	1.273
260.36	0.333	0.708	0.725	260.17	1.311	1.266	1.329	1.297
258.88	0.310	0.698	0.703	258.70	1.335	1.276	1.351	1.314
258.95	0.287	0.675	0.681	258.76	1.358	1.299	1.373	1.336
259.92	0.264	0.656	0.662	259.74	1.380	1.319	1.392	1.355
260.44	0.242	0.636	0.642	260.26	1.403	1.339	1.412	1.375
260.86	0.219	0.615	0.622	260.67	1.425	1.360	1.432	1.396
222.63	0.204	0.605	0.610	222.44	1.440	1.369	1.444	1.407
213.54	0.201	0.602	0.610	213.35	1.443	1.372	1.443	1.408
206.12	0.199	0.602	0.610	205.93	1.445	1.372	1.443	1.408
201.15	0.198	0.601	0.609	200.96	1.447	1.374	1.445	1.409
197.66	0.196	0.598	0.607	197.47	1.448	1.377	1.447	1.412
194.87	0.196	0.598	0.607	194.68	1.448	1.376	1.447	1.411
192.42	0.195	0.597	0.607	192.23	1.449	1.377	1.447	1.412
190.46	0.195	0.598	0.607	190.28	1.450	1.377	1.447	1.412
235.89	0.194	0.598	0.607	235.70	1.450	1.377	1.447	1.412
259.94	0.181	0.582	0.590	259.76	1.463	1.392	1.463	1.428
258.59	0.162	0.567	0.572	258.41	1.482	1.407	1.482	1.445
259.22	0.141	0.548	0.553	259.03	1.504	1.427	1.501	1.464
258.11	0.118	0.528	0.532	257.93	1.526	1.446	1.522	1.484
258.53	0.096	0.508	0.513	258.34	1.548	1.466	1.541	1.504
257.78	0.074	0.492	0.494	257.60	1.571	1.483	1.560	1.521
256.85	0.057	0.472	0.475	256.66	1.587	1.502	1.579	1.540
257.26	0.045	0.452	0.456	257.08	1.599	1.523	1.598	1.560
258.13	0.033	0.432	0.436	257.95	1.612	1.542	1.618	1.580
233.56	0.023	0.418	0.424	233.37	1.621	1.556	1.629	1.593
213.44	0.021	0.414	0.420	213.25	1.623	1.560	1.633	1.597
205.20	0.020	0.412	0.421	205.02	1.624	1.562	1.633	1.598
199.94	0.018	0.414	0.421	199.76	1.627	1.561	1.633	1.597
195.74	0.018	0.411	0.420	195.56	1.627	1.563	1.634	1.598
192.61	0.017	0.410	0.421	192.42	1.628	1.564	1.633	1.598
189.96	0.017	0.410	0.421	189.78	1.628	1.564	1.633	1.599
187.76	0.016	0.410	0.420	187.57	1.628	1.565	1.633	1.599
265.58	0.010	0.399	0.405	265.39	1.634	1.576	1.648	1.612
259.65	-0.006	0.369	0.377	259.47	1.651	1.605	1.677	1.641

Table A.7 Initial and zeroed readings for teflon pad test 1 (continued)

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
259.42	-0.023	0.343	0.350	259.24	1.667	1.631	1.703	1.667
258.86	-0.041	0.316	0.323	258.68	1.685	1.659	1.731	1.695
254.25	-0.055	0.296	0.301	254.06	1.699	1.678	1.753	1.715
251.75	-0.068	0.276	0.285	251.57	1.713	1.699	1.769	1.734
248.59	-0.091	0.256	0.260	248.41	1.735	1.718	1.793	1.756
220.61	-0.114	0.242	0.248	220.42	1.758	1.733	1.806	1.769
203.73	-0.119	0.242	0.248	203.54	1.763	1.733	1.805	1.769
197.93	-0.121	0.237	0.249	197.74	1.765	1.738	1.805	1.771
193.73	-0.122	0.238	0.247	193.54	1.767	1.737	1.807	1.772
190.42	-0.124	0.238	0.245	190.24	1.768	1.737	1.808	1.772

Table A.8 Initial and zeroed readings for teflon pad test 2

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
0.17	1.644	2.056	2.128	0.00	0.000	0.000	0.000	0.000
0.23	1.644	2.056	2.128	0.06	0.000	0.000	0.000	0.000
0.30	1.644	2.056	2.128	0.13	0.000	0.000	0.000	0.000
0.88	1.644	2.056	2.128	0.71	0.000	0.000	0.000	0.000
0.57	1.644	2.056	2.128	0.40	0.000	0.000	0.000	0.000
0.41	1.643	2.056	2.128	0.24	0.000	0.000	0.000	0.000
0.61	1.644	2.056	2.128	0.44	0.000	0.000	0.000	0.000
0.72	1.644	2.056	2.128	0.55	0.000	0.000	0.000	0.000
0.54	1.644	2.056	2.128	0.37	0.000	0.000	0.000	0.000
1.42	1.644	2.056	2.128	1.25	0.000	0.000	0.000	0.000
14.06	1.643	2.052	2.128	13.89	0.000	0.004	0.000	0.002
32.32	1.643	2.048	2.128	32.15	0.001	0.008	0.000	0.004
88.54	1.641	2.045	2.123	88.37	0.003	0.011	0.005	0.008
136.57	1.633	2.035	2.112	136.40	0.011	0.021	0.016	0.018
161.56	1.621	2.020	2.089	161.39	0.022	0.036	0.039	0.038
170.25	1.606	2.004	2.056	170.08	0.038	0.052	0.072	0.062
171.86	1.588	1.980	2.046	171.69	0.055	0.076	0.082	0.079
173.87	1.568	1.958	1.961	173.70	0.076	0.098	0.167	0.132
149.14	1.546	1.936	1.992	148.97	0.097	0.120	0.136	0.128
141.09	1.543	1.932	2.008	140.92	0.100	0.124	0.121	0.122
135.90	1.542	1.931	2.006	135.73	0.101	0.125	0.122	0.124
132.65	1.541	1.927	2.003	132.48	0.102	0.129	0.125	0.127
130.22	1.541	1.928	2.002	130.05	0.102	0.128	0.126	0.127
128.33	1.541	1.928	2.003	128.16	0.103	0.128	0.125	0.127
126.88	1.540	1.928	2.004	126.71	0.103	0.128	0.124	0.126
125.56	1.540	1.928	2.004	125.39	0.104	0.128	0.124	0.126
124.45	1.540	1.927	2.003	124.28	0.104	0.129	0.125	0.127
126.23	1.539	1.920	2.003	126.06	0.104	0.136	0.125	0.131
174.38	1.528	1.909	1.959	174.21	0.116	0.147	0.169	0.158
171.41	1.510	1.886	1.949	171.24	0.134	0.170	0.179	0.175
168.68	1.491	1.868	1.944	168.51	0.152	0.188	0.184	0.186
165.08	1.474	1.854	1.929	164.91	0.169	0.202	0.200	0.201
162.69	1.458	1.843	1.903	162.52	0.185	0.213	0.225	0.219
161.64	1.443	1.822	1.891	161.47	0.201	0.234	0.237	0.236
160.84	1.426	1.800	1.874	160.67	0.217	0.256	0.254	0.255
160.42	1.410	1.785	1.856	160.25	0.233	0.271	0.273	0.272
159.84	1.394	1.764	1.830	159.67	0.250	0.292	0.298	0.295
138.90	1.385	1.760	1.828	138.73	0.258	0.296	0.300	0.298
133.31	1.384	1.757	1.828	133.14	0.259	0.299	0.300	0.300
129.95	1.383	1.754	1.823	129.78	0.260	0.302	0.305	0.303
127.63	1.383	1.755	1.823	127.46	0.261	0.301	0.305	0.303
125.76	1.382	1.752	1.823	125.59	0.261	0.304	0.305	0.304
124.29	1.382	1.751	1.821	124.12	0.261	0.305	0.307	0.306

Table A.8 Initial and zeroed readings for teflon pad test 2 (continued)

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
122.96	1.382	1.756	1.823	122.79	0.262	0.300	0.305	0.302
121.87	1.382	1.755	1.823	121.70	0.262	0.301	0.305	0.303
155.11	1.381	1.727	1.804	154.94	0.263	0.329	0.324	0.327
164.63	1.365	1.734	1.795	164.46	0.279	0.322	0.333	0.327
158.86	1.345	1.711	1.782	158.69	0.299	0.345	0.346	0.346
157.44	1.326	1.695	1.759	157.27	0.318	0.361	0.369	0.365
154.76	1.306	1.669	1.736	154.59	0.338	0.387	0.392	0.390
153.63	1.287	1.652	1.717	153.46	0.357	0.404	0.411	0.408
151.75	1.269	1.632	1.697	151.58	0.375	0.424	0.431	0.428
149.96	1.252	1.613	1.664	149.79	0.391	0.443	0.464	0.453
150.64	1.237	1.597	1.662	150.47	0.407	0.459	0.466	0.462
133.72	1.219	1.578	1.642	133.55	0.424	0.478	0.486	0.482
131.17	1.217	1.573	1.640	131.00	0.427	0.483	0.489	0.486
128.87	1.216	1.574	1.637	128.70	0.428	0.482	0.491	0.487
126.83	1.215	1.573	1.638	126.66	0.429	0.483	0.490	0.486
125.11	1.214	1.572	1.638	124.94	0.429	0.484	0.490	0.487
123.61	1.214	1.568	1.638	123.44	0.430	0.488	0.490	0.489
122.36	1.214	1.569	1.638	122.19	0.430	0.487	0.490	0.488
121.18	1.214	1.569	1.637	121.01	0.430	0.487	0.491	0.489
120.17	1.213	1.569	1.636	120.00	0.430	0.487	0.492	0.489
161.92	1.209	1.566	1.631	161.75	0.435	0.490	0.497	0.494
146.94	1.187	1.541	1.607	146.77	0.456	0.515	0.521	0.518
147.77	1.164	1.516	1.579	147.60	0.480	0.540	0.549	0.545
146.14	1.142	1.492	1.556	145.97	0.501	0.564	0.572	0.568
147.41	1.123	1.471	1.537	147.24	0.520	0.585	0.591	0.588
150.38	1.106	1.453	1.518	150.21	0.538	0.603	0.610	0.607
149.04	1.090	1.436	1.501	148.87	0.554	0.620	0.627	0.624
148.72	1.072	1.417	1.482	148.55	0.571	0.639	0.646	0.643
148.45	1.054	1.397	1.463	148.28	0.590	0.659	0.665	0.662
132.29	1.043	1.386	1.451	132.12	0.600	0.670	0.677	0.674
128.94	1.042	1.384	1.451	128.77	0.602	0.672	0.677	0.674
126.25	1.040	1.381	1.450	126.08	0.603	0.675	0.678	0.676
124.04	1.040	1.381	1.451	123.87	0.604	0.675	0.677	0.676
122.23	1.040	1.382	1.449	122.06	0.604	0.674	0.679	0.677
120.72	1.039	1.381	1.444	120.55	0.604	0.675	0.684	0.680
119.38	1.039	1.380	1.444	119.21	0.605	0.676	0.684	0.680
118.23	1.038	1.379	1.446	118.06	0.605	0.677	0.682	0.680
117.23	1.038	1.378	1.446	117.06	0.606	0.678	0.682	0.680
158.67	1.033	1.373	1.440	158.50	0.611	0.683	0.688	0.686
148.60	1.015	1.356	1.423	148.43	0.628	0.700	0.705	0.703
149.73	0.995	1.335	1.404	149.56	0.649	0.721	0.724	0.723
148.07	0.973	1.314	1.381	147.90	0.670	0.742	0.747	0.745
146.34	0.953	1.293	1.360	146.17	0.691	0.763	0.768	0.765

Table A.8 Initial and zeroed readings for teflon pad test 2 (continued)

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
146.38	0.934	1.273	1.342	146.21	0.709	0.783	0.787	0.785
147.45	0.917	1.256	1.324	147.28	0.727	0.800	0.804	0.802
146.86	0.899	1.238	1.304	146.69	0.745	0.818	0.824	0.821
145.03	0.879	1.210	1.287	144.86	0.765	0.846	0.842	0.844
142.23	0.858	1.195	1.265	142.06	0.786	0.861	0.863	0.862
131.06	0.854	1.182	1.261	130.89	0.790	0.874	0.867	0.870
128.45	0.853	1.191	1.260	128.28	0.791	0.865	0.868	0.866
126.22	0.852	1.135	1.261	126.05	0.791	0.921	0.867	0.894
124.36	0.852	1.185	1.261	124.19	0.792	0.871	0.867	0.869
122.83	0.851	1.182	1.260	122.66	0.792	0.874	0.868	0.871
121.53	0.851	1.184	1.258	121.36	0.793	0.872	0.870	0.871
120.42	0.851	1.166	1.258	120.25	0.793	0.890	0.870	0.880
119.56	0.850	1.170	1.258	119.39	0.793	0.886	0.870	0.878
144.21	0.837	1.175	1.245	144.04	0.806	0.881	0.883	0.882
145.04	0.817	1.154	1.222	144.87	0.827	0.902	0.906	0.904
141.92	0.797	1.137	1.204	141.75	0.846	0.919	0.925	0.922
141.25	0.780	1.121	1.186	141.08	0.864	0.935	0.942	0.938
140.00	0.763	1.079	1.166	139.83	0.881	0.977	0.963	0.970
140.29	0.745	1.085	1.146	140.12	0.898	0.971	0.982	0.976
140.65	0.726	1.065	1.132	140.48	0.917	0.991	0.997	0.994
141.04	0.706	1.046	1.115	140.87	0.937	1.010	1.013	1.011
140.67	0.684	1.016	1.095	140.50	0.959	1.040	1.033	1.037
127.52	0.669	1.010	1.080	127.35	0.975	1.046	1.048	1.047
127.44	0.667	1.010	1.079	127.27	0.976	1.046	1.049	1.048
125.99	0.667	1.008	1.078	125.82	0.977	1.048	1.050	1.049
124.54	0.666	1.005	1.078	124.37	0.977	1.051	1.051	1.051
123.22	0.666	1.006	1.077	123.05	0.978	1.050	1.051	1.051
121.87	0.665	1.006	1.077	121.70	0.978	1.050	1.051	1.051
120.76	0.665	1.005	1.077	120.59	0.978	1.051	1.051	1.051
119.71	0.665	1.006	1.076	119.54	0.978	1.050	1.052	1.051
150.57	0.664	1.007	1.076	150.40	0.979	1.049	1.053	1.051
143.65	0.647	0.989	1.058	143.48	0.997	1.067	1.070	1.069
139.91	0.624	0.963	1.032	139.74	1.019	1.093	1.096	1.095
138.63	0.601	0.945	1.015	138.46	1.042	1.111	1.113	1.112
140.30	0.579	0.924	0.986	140.13	1.064	1.132	1.142	1.137
141.64	0.558	0.904	0.967	141.47	1.085	1.152	1.161	1.157
141.00	0.539	0.890	0.954	140.83	1.105	1.166	1.174	1.170
141.19	0.517	0.870	0.937	141.02	1.127	1.186	1.191	1.189
142.15	0.494	0.850	0.917	141.98	1.149	1.206	1.211	1.209
141.40	0.469	0.828	0.894	141.23	1.174	1.228	1.234	1.231
129.22	0.460	0.819	0.886	129.05	1.183	1.237	1.242	1.239
128.17	0.459	0.818	0.886	128.00	1.185	1.238	1.242	1.240
126.91	0.458	0.817	0.885	126.74	1.186	1.239	1.243	1.241

Table A.8 Initial and zeroed readings for teflon pad test 2 (continued)

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
125.73	0.457	0.818	0.885	125.56	1.186	1.238	1.243	1.241
124.60	0.457	0.816	0.884	124.43	1.187	1.240	1.244	1.242
123.53	0.457	0.815	0.883	123.36	1.187	1.241	1.245	1.243
122.63	0.456	0.813	0.883	122.46	1.187	1.243	1.245	1.244
121.81	0.456	0.813	0.884	121.64	1.187	1.243	1.245	1.244
137.25	0.439	0.801	0.867	137.08	1.205	1.255	1.261	1.258
139.56	0.410	0.774	0.841	139.39	1.234	1.282	1.287	1.284
140.15	0.381	0.745	0.823	139.98	1.262	1.311	1.305	1.308
140.19	0.356	0.723	0.794	140.02	1.288	1.333	1.334	1.334
138.48	0.334	0.704	0.774	138.31	1.309	1.352	1.354	1.353
137.30	0.315	0.687	0.756	137.13	1.328	1.369	1.372	1.370
138.22	0.297	0.671	0.739	138.05	1.347	1.385	1.389	1.387
139.52	0.276	0.651	0.720	139.35	1.367	1.405	1.408	1.407
135.44	0.251	0.630	0.698	135.27	1.393	1.426	1.431	1.428
127.21	0.246	0.626	0.690	127.04	1.397	1.430	1.438	1.434
126.52	0.245	0.625	0.694	126.35	1.398	1.431	1.434	1.432
125.67	0.244	0.623	0.691	125.50	1.399	1.433	1.437	1.435
124.75	0.244	0.622	0.692	124.58	1.399	1.434	1.437	1.435
123.81	0.244	0.623	0.692	123.64	1.400	1.433	1.437	1.435
122.91	0.243	0.622	0.692	122.74	1.400	1.434	1.437	1.435
122.06	0.243	0.622	0.692	121.89	1.400	1.434	1.436	1.435
125.87	0.243	0.622	0.691	125.70	1.401	1.434	1.437	1.436
144.34	0.220	0.603	0.671	144.17	1.424	1.453	1.457	1.455
140.00	0.192	0.578	0.647	139.83	1.452	1.478	1.481	1.480
139.73	0.166	0.557	0.624	139.56	1.478	1.499	1.504	1.502
139.00	0.143	0.536	0.603	138.83	1.501	1.520	1.525	1.522
139.22	0.122	0.516	0.585	139.05	1.522	1.540	1.543	1.542
138.26	0.101	0.500	0.568	138.09	1.543	1.556	1.560	1.558
138.56	0.080	0.481	0.550	138.39	1.564	1.575	1.578	1.577
139.17	0.057	0.461	0.531	139.00	1.586	1.595	1.597	1.596
137.83	0.031	0.439	0.507	137.66	1.613	1.617	1.621	1.619
127.34	0.022	0.434	0.501	127.17	1.622	1.622	1.628	1.625
126.99	0.021	0.430	0.499	126.82	1.623	1.626	1.629	1.627
126.49	0.020	0.429	0.499	126.32	1.624	1.627	1.629	1.628
126.00	0.020	0.429	0.499	125.83	1.624	1.627	1.629	1.628
125.52	0.019	0.429	0.498	125.35	1.625	1.627	1.630	1.629
124.95	0.019	0.430	0.498	124.78	1.625	1.626	1.630	1.628
124.31	0.018	0.428	0.498	124.14	1.625	1.628	1.630	1.629
123.73	0.018	0.426	0.498	123.56	1.626	1.630	1.630	1.630

Table A.9 Initial and zeroed readings for teflon pad test 3

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
0.14	1.713	2.111	2.134	0.00	0.000	0.000	0.000	0.000
0.65	1.713	2.111	2.134	0.51	0.000	0.000	0.000	0.000
0.48	1.713	2.111	2.134	0.34	0.000	0.000	0.000	0.000
0.87	1.713	2.111	2.134	0.73	0.000	0.000	0.001	0.000
0.56	1.713	2.112	2.134	0.42	0.000	0.000	0.000	0.000
0.37	1.713	2.112	2.134	0.23	0.000	0.000	0.000	0.000
0.17	1.713	2.111	2.134	0.03	0.000	0.000	0.001	0.000
0.64	1.713	2.112	2.134	0.50	0.000	0.000	0.000	0.000
0.27	1.713	2.112	2.134	0.13	0.000	0.000	0.001	0.000
7.51	1.713	2.111	2.134	7.37	0.000	0.000	0.000	0.000
16.09	1.713	2.111	2.134	15.95	0.000	0.000	0.001	0.000
61.01	1.713	2.095	2.122	60.87	0.000	0.016	0.012	0.014
85.34	1.707	2.087	2.120	85.20	0.006	0.024	0.014	0.019
99.52	1.698	2.080	2.105	99.38	0.016	0.032	0.029	0.030
106.80	1.686	2.072	2.086	106.66	0.027	0.040	0.048	0.044
108.99	1.674	2.060	2.072	108.85	0.039	0.051	0.062	0.057
109.31	1.660	2.045	2.014	109.17	0.053	0.067	0.121	0.094
112.65	1.645	2.027	2.031	112.51	0.068	0.084	0.104	0.094
93.55	1.635	2.021	2.026	93.41	0.078	0.090	0.108	0.099
79.93	1.631	2.022	2.022	79.79	0.082	0.090	0.112	0.101
73.75	1.629	2.017	2.016	73.61	0.084	0.094	0.118	0.106
69.40	1.627	2.018	2.021	69.26	0.086	0.094	0.113	0.104
65.19	1.626	2.018	2.016	65.05	0.087	0.094	0.118	0.106
62.64	1.625	2.018	1.996	62.50	0.088	0.093	0.138	0.116
60.82	1.625	2.016	2.010	60.68	0.088	0.095	0.124	0.109
59.45	1.624	2.012	2.014	59.31	0.089	0.099	0.120	0.110
58.58	1.624	2.013	2.016	58.44	0.090	0.098	0.118	0.108
91.95	1.620	2.010	2.005	91.81	0.093	0.101	0.129	0.115
108.79	1.612	1.969	1.954	108.65	0.101	0.143	0.180	0.161
113.70	1.599	1.980	1.979	113.56	0.114	0.131	0.155	0.143
114.81	1.584	1.963	1.956	114.67	0.129	0.148	0.178	0.163
114.36	1.569	1.943	1.946	114.22	0.144	0.169	0.189	0.179
113.92	1.555	1.930	1.928	113.78	0.158	0.181	0.206	0.193
112.75	1.541	1.916	1.909	112.61	0.173	0.195	0.225	0.210
111.66	1.527	1.899	1.896	111.52	0.187	0.212	0.238	0.225
114.34	1.513	1.884	1.880	114.20	0.200	0.227	0.255	0.241
116.75	1.499	1.868	1.864	116.61	0.215	0.244	0.271	0.257
119.55	1.484	1.854	1.845	119.41	0.229	0.257	0.289	0.273
102.20	1.472	1.841	1.832	102.06	0.242	0.271	0.302	0.286
90.61	1.467	1.842	1.828	90.47	0.246	0.269	0.306	0.288
84.97	1.464	1.842	1.828	84.83	0.249	0.270	0.306	0.288
81.17	1.463	1.839	1.827	81.03	0.251	0.273	0.307	0.290
78.29	1.461	1.839	1.824	78.15	0.252	0.273	0.310	0.291

Table A.9 Initial and zeroed readings for teflon pad test 3 (continued)

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
75.95	1.460	1.838	1.824	75.81	0.253	0.273	0.310	0.291
73.62	1.459	1.838	1.824	73.48	0.254	0.273	0.310	0.291
71.13	1.459	1.829	1.823	70.99	0.255	0.282	0.311	0.296
69.07	1.458	1.834	1.825	68.93	0.255	0.277	0.309	0.293
67.59	1.458	1.834	1.825	67.45	0.256	0.277	0.309	0.293
106.06	1.453	1.826	1.811	105.92	0.260	0.285	0.323	0.304
119.73	1.441	1.807	1.793	119.59	0.273	0.304	0.341	0.323
128.49	1.427	1.782	1.775	128.35	0.286	0.329	0.359	0.344
130.62	1.413	1.772	1.759	130.48	0.300	0.340	0.375	0.358
130.47	1.400	1.755	1.740	130.33	0.314	0.357	0.394	0.375
128.01	1.385	1.729	1.724	127.87	0.328	0.383	0.410	0.396
127.14	1.371	1.727	1.708	127.00	0.342	0.384	0.426	0.405
128.45	1.358	1.714	1.694	128.31	0.356	0.398	0.441	0.419
130.22	1.343	1.697	1.676	130.08	0.370	0.414	0.458	0.436
132.25	1.327	1.679	1.658	132.11	0.386	0.432	0.476	0.454
114.73	1.311	1.663	1.637	114.59	0.402	0.448	0.497	0.473
105.06	1.305	1.659	1.636	104.92	0.408	0.452	0.499	0.475
98.26	1.302	1.659	1.634	98.12	0.411	0.452	0.500	0.476
93.19	1.300	1.659	1.635	93.05	0.413	0.452	0.499	0.476
89.63	1.299	1.655	1.634	89.49	0.415	0.456	0.500	0.478
86.95	1.297	1.655	1.632	86.81	0.416	0.456	0.502	0.479
84.67	1.297	1.655	1.629	84.53	0.417	0.457	0.506	0.481
83.04	1.295	1.654	1.630	82.90	0.418	0.457	0.504	0.481
81.57	1.295	1.655	1.630	81.43	0.419	0.456	0.504	0.480
81.06	1.294	1.655	1.631	80.92	0.419	0.456	0.503	0.480
116.12	1.287	1.640	1.615	115.98	0.426	0.472	0.519	0.496
132.35	1.273	1.619	1.596	132.21	0.440	0.493	0.538	0.516
135.61	1.256	1.599	1.574	135.47	0.457	0.513	0.561	0.537
132.36	1.239	1.585	1.557	132.22	0.474	0.527	0.578	0.552
129.37	1.224	1.569	1.539	129.23	0.489	0.542	0.595	0.568
127.72	1.210	1.552	1.523	127.58	0.503	0.560	0.611	0.585
129.06	1.197	1.541	1.510	128.92	0.516	0.571	0.624	0.597
129.30	1.185	1.527	1.494	129.16	0.529	0.585	0.640	0.612
130.41	1.171	1.511	1.480	130.27	0.542	0.600	0.655	0.627
133.11	1.157	1.496	1.463	132.97	0.557	0.616	0.671	0.644
124.50	1.142	1.480	1.447	124.36	0.571	0.631	0.687	0.659
111.20	1.137	1.480	1.443	111.06	0.576	0.631	0.691	0.661
103.81	1.134	1.479	1.443	103.67	0.579	0.632	0.692	0.662
99.46	1.133	1.476	1.443	99.32	0.581	0.635	0.691	0.663
96.58	1.131	1.476	1.443	96.44	0.582	0.636	0.692	0.664
94.32	1.131	1.475	1.439	94.18	0.583	0.636	0.695	0.666
92.47	1.130	1.475	1.439	92.33	0.583	0.637	0.695	0.666
91.00	1.129	1.475	1.439	90.86	0.584	0.637	0.695	0.666

Table A.9 Initial and zeroed readings for teflon pad test 3 (continued)

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
89.76	1.129	1.472	1.439	89.62	0.585	0.639	0.695	0.667
111.08	1.125	1.462	1.432	110.94	0.588	0.650	0.703	0.676
130.79	1.114	1.449	1.416	130.65	0.600	0.662	0.718	0.690
137.71	1.097	1.433	1.397	137.57	0.616	0.679	0.737	0.708
141.36	1.080	1.412	1.375	141.22	0.633	0.699	0.759	0.729
141.55	1.064	1.393	1.358	141.41	0.650	0.719	0.777	0.748
138.82	1.048	1.378	1.340	138.68	0.665	0.733	0.794	0.764
138.17	1.034	1.361	1.326	138.03	0.679	0.750	0.808	0.779
139.76	1.021	1.350	1.312	139.62	0.692	0.761	0.822	0.792
141.30	1.007	1.336	1.297	141.16	0.706	0.776	0.837	0.806
144.33	0.992	1.318	1.281	144.19	0.721	0.794	0.853	0.823
145.50	0.976	1.301	1.263	145.36	0.737	0.810	0.871	0.841
124.50	0.965	1.289	1.253	124.36	0.748	0.823	0.881	0.852
119.82	0.962	1.289	1.253	119.68	0.751	0.822	0.881	0.852
116.17	0.960	1.289	1.252	116.03	0.753	0.822	0.882	0.852
113.78	0.959	1.283	1.250	113.64	0.754	0.828	0.884	0.856
112.07	0.958	1.284	1.249	111.93	0.756	0.827	0.885	0.856
110.71	0.957	1.285	1.249	110.57	0.756	0.827	0.885	0.856
109.57	0.957	1.284	1.249	109.43	0.757	0.827	0.885	0.856
108.68	0.956	1.285	1.248	108.54	0.757	0.826	0.886	0.856
135.91	0.952	1.277	1.242	135.77	0.761	0.834	0.892	0.863
148.39	0.940	1.262	1.225	148.25	0.773	0.849	0.909	0.879
151.82	0.925	1.243	1.209	151.68	0.788	0.868	0.925	0.897
151.96	0.910	1.223	1.192	151.82	0.803	0.889	0.942	0.915
150.15	0.895	1.210	1.176	150.01	0.818	0.901	0.958	0.930
150.86	0.881	1.199	1.163	150.72	0.832	0.913	0.971	0.942
152.63	0.868	1.167	1.149	152.49	0.846	0.944	0.985	0.964
155.54	0.853	1.165	1.133	155.40	0.860	0.947	1.001	0.974
158.58	0.837	1.123	1.115	158.44	0.877	0.988	1.019	1.004
160.65	0.818	1.138	1.096	160.51	0.895	0.974	1.038	1.006
162.21	0.798	1.101	1.077	162.07	0.916	1.010	1.057	1.034
151.56	0.780	1.101	1.061	151.42	0.933	1.010	1.073	1.041
132.76	0.776	1.096	1.058	132.62	0.937	1.016	1.076	1.046
127.43	0.774	1.093	1.058	127.29	0.939	1.018	1.076	1.047
124.37	0.773	1.094	1.057	124.23	0.940	1.018	1.077	1.047
121.93	0.772	1.093	1.057	121.79	0.941	1.018	1.077	1.047
119.99	0.771	1.093	1.056	119.85	0.942	1.019	1.078	1.048
118.38	0.770	1.091	1.057	118.24	0.943	1.020	1.077	1.048
141.79	0.768	1.025	1.050	141.65	0.945	1.086	1.084	1.085
160.55	0.756	1.064	1.035	160.41	0.958	1.048	1.099	1.073
161.40	0.738	0.988	1.012	161.26	0.975	1.124	1.122	1.123
161.22	0.721	1.040	0.998	161.08	0.992	1.072	1.136	1.104
161.10	0.705	1.017	0.983	160.96	1.008	1.094	1.151	1.122

Table A.9 Initial and zeroed readings for teflon pad test 3 (continued)

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
158.77	0.691	1.002	0.968	158.63	1.023	1.109	1.166	1.137
160.11	0.677	0.998	0.954	159.97	1.037	1.113	1.180	1.146
159.79	0.663	0.983	0.941	159.65	1.050	1.129	1.193	1.161
160.62	0.649	0.970	0.927	160.48	1.064	1.141	1.207	1.174
160.41	0.635	0.957	0.914	160.27	1.079	1.154	1.221	1.187
161.83	0.617	0.944	0.899	161.69	1.096	1.168	1.235	1.202
150.26	0.603	0.928	0.884	150.12	1.111	1.183	1.250	1.217
137.96	0.598	0.926	0.883	137.82	1.115	1.186	1.251	1.218
131.93	0.596	0.924	0.882	131.79	1.117	1.188	1.252	1.220
128.28	0.595	0.924	0.881	128.14	1.119	1.188	1.253	1.220
125.66	0.594	0.923	0.881	125.52	1.119	1.189	1.253	1.221
123.67	0.593	0.921	0.881	123.53	1.120	1.190	1.253	1.222
122.03	0.593	0.921	0.881	121.89	1.121	1.191	1.253	1.222
121.91	0.592	0.920	0.880	121.77	1.122	1.191	1.254	1.222
155.82	0.582	0.908	0.866	155.68	1.131	1.203	1.268	1.236
166.40	0.564	0.892	0.848	166.26	1.149	1.220	1.286	1.253
168.48	0.544	0.873	0.828	168.34	1.169	1.238	1.306	1.272
165.25	0.525	0.856	0.809	165.11	1.189	1.256	1.325	1.290
163.42	0.506	0.842	0.793	163.28	1.207	1.269	1.341	1.305
160.23	0.490	0.825	0.778	160.09	1.223	1.286	1.356	1.321
159.91	0.475	0.813	0.763	159.77	1.238	1.298	1.371	1.335
160.47	0.461	0.801	0.750	160.33	1.253	1.310	1.384	1.347
159.76	0.447	0.785	0.739	159.62	1.266	1.327	1.395	1.361
158.90	0.434	0.774	0.725	158.76	1.280	1.338	1.409	1.374
159.93	0.421	0.762	0.712	159.79	1.293	1.349	1.422	1.386
163.70	0.407	0.751	0.699	163.56	1.307	1.360	1.435	1.398
142.28	0.395	0.744	0.688	142.14	1.318	1.368	1.446	1.407
136.50	0.392	0.738	0.688	136.36	1.321	1.373	1.446	1.409
131.98	0.391	0.738	0.688	131.84	1.323	1.373	1.446	1.410
129.41	0.390	0.735	0.688	129.27	1.324	1.377	1.446	1.411
127.49	0.389	0.734	0.688	127.35	1.324	1.377	1.446	1.412
125.88	0.389	0.734	0.688	125.74	1.325	1.377	1.446	1.412
124.56	0.388	0.734	0.688	124.42	1.326	1.377	1.447	1.412
135.15	0.387	0.734	0.688	135.01	1.326	1.377	1.447	1.412
166.90	0.377	0.723	0.675	166.76	1.336	1.389	1.460	1.424
166.12	0.362	0.708	0.661	165.98	1.351	1.404	1.473	1.439
166.42	0.347	0.696	0.646	166.28	1.366	1.416	1.488	1.452
165.29	0.331	0.683	0.632	165.15	1.382	1.428	1.502	1.465
165.92	0.317	0.669	0.619	165.78	1.397	1.442	1.515	1.479
165.18	0.302	0.656	0.606	165.04	1.411	1.455	1.528	1.492
166.74	0.287	0.644	0.591	166.60	1.426	1.467	1.543	1.505
168.03	0.270	0.630	0.576	167.89	1.443	1.481	1.558	1.519
168.88	0.251	0.614	0.557	168.74	1.462	1.498	1.577	1.538

Table A.9 Initial and zeroed readings for teflon pad test 3 (continued)

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
168.72	0.230	0.595	0.539	168.58	1.483	1.516	1.595	1.556
170.26	0.209	0.578	0.519	170.12	1.504	1.533	1.615	1.574
167.60	0.188	0.560	0.499	167.46	1.525	1.551	1.635	1.593
143.18	0.178	0.551	0.495	143.04	1.535	1.560	1.640	1.600
133.67	0.175	0.551	0.494	133.53	1.538	1.560	1.640	1.600
129.39	0.174	0.547	0.492	129.25	1.540	1.564	1.642	1.603
126.45	0.172	0.547	0.492	126.31	1.541	1.564	1.642	1.603
124.27	0.172	0.547	0.491	124.13	1.542	1.564	1.643	1.604
122.58	0.171	0.545	0.491	122.44	1.542	1.567	1.643	1.605
121.11	0.170	0.544	0.491	120.97	1.543	1.567	1.643	1.605
145.09	0.167	0.540	0.485	144.95	1.546	1.571	1.649	1.610
166.35	0.152	0.527	0.469	166.21	1.562	1.585	1.665	1.625
166.22	0.134	0.513	0.455	166.08	1.579	1.598	1.679	1.639
167.62	0.119	0.498	0.441	167.48	1.595	1.613	1.693	1.653
167.85	0.103	0.485	0.428	167.71	1.610	1.627	1.706	1.666
167.52	0.088	0.473	0.414	167.38	1.626	1.639	1.720	1.680
166.78	0.074	0.461	0.406	166.64	1.640	1.651	1.728	1.689
166.57	0.060	0.448	0.390	166.43	1.654	1.664	1.744	1.704
165.79	0.047	0.438	0.378	165.65	1.667	1.674	1.756	1.715
166.47	0.033	0.425	0.371	166.33	1.681	1.686	1.763	1.725
167.32	0.020	0.414	0.361	167.18	1.694	1.697	1.773	1.735
168.81	0.007	0.403	0.348	168.67	1.707	1.708	1.786	1.747
168.67	0.005	0.403	0.347	168.53	1.708	1.709	1.787	1.748
168.42	0.003	0.402	0.344	168.28	1.710	1.709	1.791	1.750
168.73	0.002	0.400	0.342	168.59	1.711	1.712	1.792	1.752
169.22	0.001	0.399	0.342	169.08	1.712	1.712	1.792	1.752

Table A.10 Initial and zeroed readings for teflon pad test 4

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
0.11	1.417	1.954	1.881	0.00	0.000	0.000	0.000	0.000
0.21	1.417	1.954	1.882	0.10	0.000	0.000	0.000	0.000
0.89	1.417	1.954	1.881	0.78	0.000	0.000	0.000	0.000
0.44	1.417	1.955	1.881	0.33	0.000	0.000	0.000	0.000
0.14	1.417	1.954	1.881	0.03	0.000	0.000	0.000	0.000
0.15	1.417	1.954	1.881	0.04	0.000	0.000	0.000	0.000
0.40	1.417	1.955	1.881	0.29	0.000	0.000	0.000	0.000
0.74	1.417	1.954	1.882	0.63	0.000	0.000	0.000	0.000
6.67	1.417	1.953	1.882	6.56	0.000	0.002	0.000	0.001
7.24	1.415	1.943	1.872	7.13	0.002	0.011	0.009	0.010
9.61	1.412	1.932	1.859	9.50	0.005	0.022	0.022	0.022
12.34	1.409	1.921	1.848	12.23	0.007	0.034	0.033	0.033
28.23	1.405	1.902	1.835	28.12	0.011	0.052	0.046	0.049
53.46	1.401	1.892	1.821	53.35	0.016	0.062	0.060	0.061
75.55	1.395	1.866	1.802	75.44	0.022	0.088	0.080	0.084
83.14	1.388	1.852	1.790	83.03	0.029	0.102	0.092	0.097
78.80	1.387	1.858	1.790	78.69	0.030	0.097	0.092	0.094
79.41	1.386	1.855	1.788	79.30	0.031	0.100	0.093	0.096
78.96	1.386	1.848	1.787	78.85	0.031	0.106	0.094	0.100
78.30	1.386	1.852	1.786	78.19	0.031	0.103	0.095	0.099
77.83	1.385	1.853	1.786	77.72	0.031	0.101	0.095	0.098
77.28	1.385	1.854	1.785	77.17	0.032	0.100	0.097	0.098
76.84	1.385	1.854	1.785	76.73	0.032	0.100	0.096	0.098
76.38	1.385	1.854	1.785	76.27	0.032	0.100	0.097	0.098
75.96	1.385	1.854	1.785	75.85	0.032	0.100	0.096	0.098
87.48	1.384	1.845	1.781	87.37	0.033	0.109	0.100	0.105
113.14	1.380	1.843	1.775	113.03	0.037	0.112	0.106	0.109
137.46	1.372	1.819	1.763	137.35	0.045	0.135	0.118	0.127
164.41	1.363	1.807	1.751	164.30	0.053	0.147	0.131	0.139
160.92	1.351	1.794	1.731	160.81	0.065	0.160	0.150	0.155
162.66	1.342	1.780	1.720	162.55	0.075	0.175	0.161	0.168
164.51	1.329	1.764	1.704	164.40	0.088	0.190	0.177	0.184
166.97	1.316	1.748	1.690	166.86	0.101	0.206	0.192	0.199
168.09	1.302	1.730	1.673	167.98	0.115	0.224	0.208	0.216
168.90	1.288	1.717	1.658	168.79	0.129	0.237	0.223	0.230
170.26	1.273	1.701	1.642	170.15	0.143	0.253	0.239	0.246
171.84	1.259	1.687	1.625	171.73	0.158	0.268	0.257	0.262
158.05	1.248	1.675	1.611	157.94	0.169	0.279	0.270	0.275
145.76	1.245	1.675	1.611	145.65	0.172	0.279	0.270	0.275
139.84	1.243	1.672	1.610	139.73	0.174	0.282	0.272	0.277
134.34	1.242	1.669	1.607	134.23	0.175	0.285	0.274	0.279
130.08	1.240	1.670	1.607	129.97	0.177	0.284	0.274	0.279
126.51	1.239	1.671	1.607	126.40	0.178	0.283	0.274	0.279

Table A.10 Initial and zeroed readings for teflon pad test 4 (continued)

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
123.50	1.238	1.671	1.606	123.39	0.179	0.284	0.275	0.280
120.92	1.238	1.670	1.603	120.81	0.179	0.284	0.278	0.281
118.66	1.237	1.671	1.604	118.55	0.180	0.284	0.278	0.281
116.58	1.236	1.671	1.604	116.47	0.181	0.284	0.278	0.281
131.31	1.235	1.671	1.599	131.20	0.182	0.283	0.282	0.283
167.63	1.230	1.659	1.592	167.52	0.187	0.295	0.290	0.292
170.06	1.217	1.643	1.579	169.95	0.199	0.311	0.302	0.307
170.52	1.204	1.629	1.564	170.41	0.213	0.326	0.317	0.321
171.09	1.192	1.613	1.549	170.98	0.225	0.341	0.332	0.336
170.69	1.179	1.601	1.533	170.58	0.238	0.353	0.348	0.351
171.59	1.166	1.585	1.520	171.48	0.251	0.370	0.362	0.366
170.99	1.152	1.573	1.504	170.88	0.264	0.381	0.378	0.379
171.36	1.139	1.558	1.490	171.25	0.278	0.396	0.392	0.394
171.80	1.125	1.542	1.474	171.69	0.292	0.413	0.407	0.410
171.46	1.111	1.530	1.459	171.35	0.306	0.424	0.422	0.423
172.16	1.096	1.515	1.441	172.05	0.321	0.439	0.440	0.440
171.91	1.080	1.497	1.424	171.80	0.336	0.457	0.458	0.458
139.69	1.072	1.495	1.420	139.58	0.344	0.460	0.461	0.461
128.91	1.069	1.495	1.416	128.80	0.348	0.460	0.465	0.462
123.26	1.067	1.494	1.412	123.15	0.350	0.460	0.469	0.465
119.22	1.065	1.495	1.412	119.11	0.351	0.460	0.470	0.465
116.45	1.064	1.494	1.413	116.34	0.352	0.461	0.469	0.465
114.07	1.064	1.494	1.412	113.96	0.353	0.461	0.469	0.465
112.07	1.063	1.493	1.409	111.96	0.354	0.461	0.473	0.467
110.42	1.062	1.493	1.408	110.31	0.355	0.461	0.473	0.467
127.38	1.061	1.491	1.408	127.27	0.356	0.463	0.473	0.468
160.99	1.054	1.479	1.397	160.88	0.363	0.475	0.484	0.480
169.18	1.042	1.462	1.383	169.07	0.375	0.493	0.498	0.495
169.92	1.026	1.446	1.365	169.81	0.390	0.509	0.516	0.512
168.94	1.011	1.432	1.349	168.83	0.405	0.522	0.532	0.527
166.37	0.997	1.417	1.334	166.26	0.420	0.537	0.547	0.542
164.85	0.983	1.405	1.319	164.74	0.434	0.549	0.562	0.556
164.50	0.969	1.393	1.305	164.39	0.448	0.561	0.577	0.569
163.60	0.956	1.379	1.290	163.49	0.461	0.576	0.591	0.583
163.51	0.941	1.367	1.275	163.40	0.476	0.587	0.606	0.597
166.30	0.926	1.350	1.258	166.19	0.491	0.604	0.624	0.614
165.28	0.907	1.333	1.239	165.17	0.510	0.621	0.643	0.632
150.52	0.891	1.318	1.222	150.41	0.526	0.636	0.659	0.648
130.21	0.885	1.318	1.219	130.10	0.532	0.636	0.662	0.649
122.26	0.882	1.317	1.218	122.15	0.535	0.637	0.664	0.650
117.28	0.880	1.317	1.216	117.17	0.537	0.637	0.666	0.651
113.88	0.878	1.317	1.214	113.77	0.539	0.638	0.668	0.653
111.20	0.877	1.317	1.214	111.09	0.539	0.637	0.668	0.653

Table A.10 Initial and zeroed readings for teflon pad test 4 (continued)

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
108.96	0.876	1.317	1.213	108.85	0.540	0.637	0.668	0.653
107.08	0.875	1.317	1.212	106.97	0.541	0.637	0.670	0.653
127.97	0.873	1.313	1.208	127.86	0.544	0.642	0.674	0.658
156.67	0.864	1.298	1.195	156.56	0.553	0.656	0.686	0.671
161.18	0.850	1.286	1.181	161.07	0.567	0.669	0.700	0.684
160.85	0.834	1.267	1.164	160.74	0.583	0.688	0.717	0.702
160.34	0.817	1.245	1.148	160.23	0.600	0.710	0.734	0.722
158.67	0.801	1.239	1.130	158.56	0.616	0.716	0.752	0.734
156.84	0.785	1.222	1.115	156.73	0.632	0.733	0.766	0.749
154.90	0.770	1.209	1.101	154.79	0.647	0.745	0.780	0.763
154.26	0.756	1.195	1.086	154.15	0.661	0.759	0.795	0.777
152.07	0.740	1.182	1.072	151.96	0.677	0.773	0.809	0.791
152.56	0.725	1.120	1.053	152.45	0.692	0.835	0.829	0.832
151.01	0.708	1.145	1.038	150.90	0.709	0.809	0.843	0.826
133.86	0.691	1.133	1.023	133.75	0.726	0.821	0.859	0.840
117.74	0.686	1.140	1.019	117.63	0.731	0.814	0.863	0.839
110.25	0.682	1.141	1.015	110.14	0.734	0.813	0.866	0.840
106.33	0.681	1.141	1.014	106.22	0.736	0.813	0.867	0.840
103.16	0.679	1.141	1.012	103.05	0.738	0.813	0.869	0.841
100.69	0.678	1.141	1.011	100.58	0.739	0.813	0.870	0.842
98.60	0.677	1.141	1.011	98.49	0.740	0.814	0.870	0.842
96.78	0.676	1.141	1.010	96.67	0.741	0.813	0.871	0.842
118.59	0.674	1.130	1.007	118.48	0.743	0.825	0.874	0.849
145.14	0.664	1.114	0.995	145.03	0.753	0.841	0.887	0.864
149.28	0.647	1.104	0.976	149.17	0.769	0.850	0.905	0.878
148.93	0.629	1.072	0.960	148.82	0.788	0.883	0.922	0.902
145.73	0.610	1.050	0.941	145.62	0.806	0.904	0.940	0.922
142.85	0.593	1.056	0.926	142.74	0.823	0.898	0.956	0.927
139.70	0.579	1.035	0.912	139.59	0.838	0.919	0.969	0.944
137.66	0.565	1.027	0.897	137.55	0.852	0.928	0.984	0.956
136.45	0.552	1.015	0.885	136.34	0.865	0.939	0.996	0.968
135.97	0.539	1.012	0.874	135.86	0.878	0.942	1.007	0.975
136.50	0.526	1.001	0.860	136.39	0.891	0.953	1.022	0.987
138.88	0.511	0.989	0.848	138.77	0.906	0.965	1.034	0.999
141.82	0.494	0.969	0.831	141.71	0.923	0.985	1.050	1.018
118.20	0.481	0.965	0.821	118.09	0.935	0.989	1.060	1.025
104.49	0.477	0.958	0.818	104.38	0.940	0.996	1.064	1.030
97.67	0.474	0.962	0.818	97.56	0.943	0.993	1.064	1.028
93.53	0.472	0.962	0.814	93.42	0.945	0.992	1.067	1.030
90.64	0.471	0.961	0.813	90.53	0.946	0.993	1.068	1.031
88.38	0.469	0.962	0.813	88.27	0.947	0.992	1.069	1.031
86.52	0.468	0.963	0.810	86.41	0.949	0.992	1.072	1.032
109.92	0.465	0.958	0.806	109.81	0.951	0.996	1.075	1.035

Table A.10 Initial and zeroed readings for teflon pad test 4 (continued)

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
135.57	0.456	0.945	0.798	135.46	0.961	1.010	1.083	1.047
139.54	0.441	0.932	0.783	139.43	0.976	1.022	1.099	1.061
139.68	0.425	0.916	0.768	139.57	0.992	1.039	1.113	1.076
138.68	0.408	0.903	0.750	138.57	1.009	1.051	1.131	1.091
135.67	0.393	0.891	0.738	135.56	1.024	1.063	1.143	1.103
133.44	0.379	0.880	0.723	133.33	1.037	1.074	1.158	1.116
131.74	0.365	0.870	0.711	131.63	1.051	1.084	1.170	1.127
131.55	0.351	0.858	0.699	131.44	1.066	1.097	1.182	1.139
133.88	0.336	0.844	0.683	133.77	1.081	1.110	1.198	1.154
136.10	0.318	0.829	0.666	135.99	1.099	1.125	1.215	1.170
137.76	0.298	0.814	0.650	137.65	1.119	1.140	1.231	1.186
137.13	0.277	0.796	0.631	137.02	1.140	1.158	1.250	1.204
109.26	0.264	0.789	0.623	109.15	1.153	1.165	1.258	1.212
96.75	0.259	0.785	0.619	96.64	1.157	1.170	1.262	1.216
90.42	0.256	0.785	0.615	90.31	1.160	1.170	1.266	1.218
86.40	0.254	0.785	0.615	86.29	1.162	1.169	1.267	1.218
83.46	0.253	0.785	0.615	83.35	1.164	1.169	1.267	1.218
81.28	0.252	0.785	0.611	81.17	1.165	1.169	1.270	1.220
79.58	0.250	0.785	0.611	79.47	1.166	1.169	1.270	1.220
123.86	0.244	0.773	0.604	123.75	1.173	1.182	1.277	1.230
134.36	0.227	0.759	0.588	134.25	1.189	1.195	1.293	1.244
135.22	0.209	0.742	0.568	135.11	1.208	1.213	1.313	1.263
133.63	0.190	0.723	0.555	133.52	1.227	1.232	1.326	1.279
129.99	0.173	0.711	0.540	129.88	1.244	1.244	1.342	1.293
126.21	0.157	0.698	0.521	126.10	1.260	1.257	1.360	1.308
125.17	0.143	0.686	0.509	125.06	1.274	1.268	1.372	1.320
124.60	0.129	0.676	0.499	124.49	1.287	1.279	1.383	1.331
125.28	0.115	0.665	0.486	125.17	1.302	1.290	1.395	1.342
127.07	0.099	0.653	0.472	126.96	1.317	1.302	1.409	1.356
128.58	0.082	0.641	0.457	128.47	1.335	1.313	1.424	1.369
128.19	0.063	0.627	0.441	128.08	1.354	1.327	1.440	1.384
111.78	0.044	0.611	0.425	111.67	1.373	1.343	1.456	1.400
91.88	0.037	0.609	0.421	91.77	1.380	1.345	1.460	1.403
83.36	0.033	0.607	0.421	83.25	1.383	1.348	1.461	1.404
78.60	0.031	0.607	0.418	78.49	1.386	1.348	1.463	1.405
75.29	0.029	0.606	0.417	75.18	1.388	1.348	1.464	1.406
72.75	0.027	0.605	0.417	72.64	1.389	1.350	1.465	1.407
70.77	0.026	0.605	0.414	70.66	1.391	1.349	1.467	1.408

Table A.11 Initial and zeroed readings for wax lubricant test 1

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
0.12	1.377	2.030	2.058	0.00	0.000	0.000	0.000	0.000
0.19	1.377	2.029	2.058	0.07	0.000	0.000	0.000	0.000
0.43	1.377	2.030	2.059	0.31	0.000	0.000	-0.001	0.000
0.19	1.377	2.030	2.058	0.07	0.000	0.000	0.000	0.000
0.37	1.377	2.030	2.058	0.24	0.000	0.000	0.000	0.000
0.17	1.377	2.030	2.058	0.05	0.000	0.000	0.000	0.000
0.23	1.377	2.029	2.057	0.11	0.000	0.001	0.001	0.001
0.29	1.377	2.030	2.058	0.17	0.000	0.000	0.000	0.000
0.59	1.376	2.029	2.058	0.46	0.000	0.001	0.000	0.000
0.34	1.376	2.030	2.058	0.22	0.000	0.000	0.000	0.000
0.26	1.377	2.030	2.058	0.14	0.000	0.000	0.000	0.000
1.59	1.377	2.029	2.058	1.46	0.000	0.001	0.000	0.000
8.30	1.377	2.021	2.037	8.18	0.000	0.009	0.021	0.015
22.88	1.377	2.017	2.050	22.75	0.000	0.013	0.009	0.011
104.10	1.377	2.006	2.023	103.98	0.000	0.024	0.035	0.030
105.97	1.375	1.984	1.980	105.85	0.002	0.046	0.078	0.062
100.19	1.356	1.963	1.995	100.07	0.021	0.067	0.064	0.065
97.64	1.350	1.954	1.990	97.51	0.027	0.076	0.068	0.072
95.02	1.348	1.955	1.989	94.89	0.029	0.074	0.069	0.072
94.71	1.347	1.951	1.988	94.58	0.030	0.079	0.070	0.074
95.79	1.346	1.949	1.988	95.66	0.031	0.081	0.070	0.075
96.29	1.346	1.950	1.985	96.16	0.031	0.079	0.073	0.076
96.93	1.346	1.951	1.983	96.81	0.031	0.078	0.075	0.077
97.51	1.345	1.951	1.984	97.39	0.032	0.079	0.074	0.076
98.09	1.345	1.951	1.985	97.97	0.032	0.079	0.074	0.076
106.45	1.345	1.951	1.984	106.33	0.032	0.079	0.074	0.076
109.61	1.332	1.934	1.967	109.49	0.045	0.096	0.091	0.093
88.86	1.312	1.907	1.948	88.74	0.065	0.123	0.110	0.117
100.51	1.295	1.884	1.930	100.38	0.082	0.146	0.129	0.137
97.12	1.277	1.874	1.908	96.99	0.100	0.156	0.150	0.153
96.51	1.261	1.848	1.891	96.39	0.116	0.181	0.167	0.174
100.71	1.244	1.837	1.870	100.59	0.133	0.193	0.188	0.190
98.47	1.227	1.815	1.851	98.34	0.149	0.215	0.207	0.211
100.51	1.210	1.799	1.836	100.38	0.167	0.231	0.222	0.226
97.14	1.193	1.777	1.813	97.01	0.184	0.253	0.245	0.249
94.04	1.182	1.768	1.804	93.92	0.195	0.261	0.254	0.258
96.14	1.180	1.764	1.802	96.02	0.197	0.265	0.257	0.261
97.08	1.179	1.764	1.802	96.95	0.198	0.266	0.256	0.261
97.60	1.179	1.764	1.801	97.47	0.198	0.265	0.257	0.261
97.51	1.178	1.763	1.798	97.39	0.199	0.267	0.260	0.263
97.84	1.178	1.760	1.797	97.72	0.199	0.269	0.261	0.265
98.26	1.177	1.761	1.798	98.14	0.199	0.269	0.261	0.265
98.76	1.177	1.760	1.798	98.63	0.200	0.270	0.260	0.265

Table A.11 Initial and zeroed readings for wax lubricant test 1 (continued)

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
99.47	1.177	1.761	1.798	99.34	0.200	0.269	0.260	0.264
88.78	1.164	1.744	1.785	88.66	0.213	0.286	0.273	0.280
106.99	1.151	1.727	1.771	106.87	0.226	0.302	0.287	0.295
93.19	1.133	1.709	1.752	93.06	0.244	0.321	0.307	0.314
97.78	1.116	1.691	1.732	97.66	0.261	0.339	0.327	0.333
98.74	1.100	1.674	1.717	98.61	0.277	0.355	0.341	0.348
97.93	1.084	1.658	1.700	97.80	0.293	0.372	0.358	0.365
96.43	1.068	1.639	1.680	96.31	0.309	0.390	0.378	0.384
96.02	1.050	1.620	1.666	95.89	0.327	0.410	0.392	0.401
93.77	1.031	1.598	1.647	93.65	0.346	0.431	0.412	0.422
92.07	1.012	1.581	1.626	91.94	0.365	0.449	0.432	0.440
92.46	1.005	1.574	1.618	92.34	0.371	0.456	0.440	0.448
91.50	1.004	1.574	1.619	91.38	0.373	0.456	0.439	0.448
91.84	1.003	1.572	1.618	91.71	0.374	0.458	0.440	0.449
92.92	1.002	1.568	1.618	92.79	0.375	0.461	0.441	0.451
93.58	1.001	1.569	1.617	93.46	0.376	0.461	0.441	0.451
94.19	1.001	1.569	1.613	94.06	0.376	0.461	0.445	0.453
95.20	1.001	1.569	1.614	95.08	0.376	0.461	0.444	0.452
96.10	1.000	1.570	1.615	95.97	0.376	0.460	0.443	0.452
93.21	0.994	1.560	1.607	93.08	0.382	0.469	0.451	0.460
84.83	0.977	1.543	1.592	84.71	0.400	0.487	0.466	0.477
96.99	0.960	1.526	1.575	96.87	0.417	0.503	0.483	0.493
93.40	0.941	1.505	1.557	93.27	0.436	0.524	0.501	0.513
93.29	0.923	1.487	1.541	93.17	0.454	0.542	0.518	0.530
94.41	0.906	1.469	1.522	94.29	0.471	0.560	0.536	0.548
93.67	0.888	1.452	1.504	93.54	0.489	0.578	0.554	0.566
92.67	0.869	1.435	1.486	92.54	0.508	0.595	0.572	0.584
94.79	0.850	1.414	1.469	94.66	0.526	0.616	0.589	0.602
94.56	0.830	1.392	1.450	94.44	0.547	0.637	0.608	0.623
89.42	0.816	1.381	1.435	89.30	0.561	0.649	0.623	0.636
90.19	0.814	1.380	1.435	90.07	0.563	0.649	0.623	0.636
90.53	0.812	1.377	1.430	90.40	0.564	0.653	0.628	0.640
90.15	0.811	1.378	1.431	90.03	0.566	0.652	0.627	0.640
90.94	0.811	1.378	1.431	90.82	0.566	0.652	0.628	0.640
91.40	0.811	1.377	1.431	91.28	0.566	0.653	0.627	0.640
91.61	0.810	1.377	1.430	91.48	0.567	0.653	0.628	0.640
93.81	0.810	1.377	1.431	93.69	0.567	0.653	0.628	0.640
108.95	0.794	1.358	1.416	108.82	0.583	0.672	0.642	0.657
92.25	0.771	1.336	1.392	92.13	0.605	0.694	0.666	0.680
95.66	0.749	1.315	1.372	95.54	0.627	0.715	0.686	0.701
97.82	0.729	1.294	1.353	97.70	0.648	0.736	0.705	0.721
99.11	0.709	1.271	1.334	98.99	0.668	0.758	0.724	0.741
100.26	0.690	1.254	1.315	100.13	0.687	0.776	0.743	0.760

Table A.11 Initial and zeroed readings for wax lubricant test 1 (continued)

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
100.92	0.670	1.235	1.297	100.80	0.707	0.794	0.761	0.778
99.09	0.650	1.213	1.275	98.97	0.727	0.816	0.783	0.800
102.34	0.628	1.194	1.253	102.21	0.749	0.835	0.805	0.820
101.19	0.619	1.070	1.245	101.07	0.758	0.960	0.813	0.887
98.30	0.617	1.175	1.243	98.18	0.760	0.854	0.815	0.835
98.80	0.615	1.175	1.241	98.68	0.762	0.855	0.818	0.836
100.21	0.615	1.181	1.240	100.09	0.762	0.848	0.818	0.833
100.78	0.614	1.182	1.240	100.65	0.763	0.848	0.818	0.833
101.65	0.614	1.183	1.240	101.52	0.763	0.847	0.818	0.833
102.69	0.613	1.183	1.241	102.56	0.763	0.847	0.818	0.832
103.69	0.613	1.182	1.241	103.56	0.764	0.847	0.818	0.833
75.20	0.600	1.131	1.226	75.08	0.777	0.898	0.832	0.865
103.37	0.583	1.156	1.208	103.25	0.794	0.874	0.850	0.862
110.01	0.564	1.136	1.188	109.88	0.813	0.893	0.870	0.882
107.82	0.543	1.089	1.168	107.70	0.834	0.941	0.890	0.915
109.22	0.524	1.091	1.151	109.09	0.853	0.938	0.908	0.923
111.75	0.505	1.074	1.130	111.63	0.872	0.955	0.928	0.942
111.50	0.485	0.963	1.114	111.38	0.892	1.067	0.944	1.006
112.46	0.464	1.018	1.094	112.34	0.913	1.012	0.964	0.988
115.35	0.443	0.978	1.076	115.23	0.934	1.052	0.982	1.017
118.11	0.420	0.988	1.052	117.99	0.956	1.042	1.006	1.024
120.13	0.412	1.001	1.050	120.01	0.964	1.029	1.009	1.019
116.70	0.411	0.998	1.046	116.58	0.966	1.032	1.012	1.022
117.35	0.409	0.998	1.046	117.22	0.967	1.032	1.013	1.022
118.26	0.409	0.998	1.045	118.14	0.968	1.032	1.013	1.022
118.84	0.408	0.997	1.045	118.72	0.968	1.033	1.013	1.023
119.90	0.408	0.998	1.046	119.78	0.969	1.032	1.013	1.022
121.32	0.408	0.998	1.044	121.19	0.969	1.032	1.014	1.023
122.90	0.408	0.996	1.043	122.77	0.969	1.033	1.015	1.024
106.37	0.389	0.974	1.026	106.24	0.988	1.056	1.032	1.044
124.87	0.368	0.950	1.007	124.75	1.009	1.080	1.051	1.066
112.67	0.342	0.932	0.984	112.54	1.034	1.098	1.074	1.086
113.29	0.318	0.915	0.962	113.17	1.059	1.115	1.097	1.106
115.14	0.294	0.892	0.940	115.02	1.083	1.137	1.118	1.128
118.68	0.270	0.871	0.919	118.55	1.106	1.158	1.139	1.149
118.63	0.246	0.851	0.897	118.51	1.131	1.179	1.161	1.170
119.84	0.221	0.828	0.875	119.72	1.156	1.201	1.183	1.192
94.66	0.197	0.809	0.854	94.54	1.179	1.221	1.204	1.213
111.36	0.195	0.810	0.852	111.23	1.181	1.220	1.206	1.213
112.29	0.194	0.809	0.852	112.17	1.183	1.220	1.206	1.213
112.56	0.193	0.805	0.852	112.44	1.184	1.225	1.206	1.215
113.71	0.192	0.805	0.850	113.58	1.184	1.225	1.208	1.216
115.39	0.192	0.805	0.850	115.27	1.185	1.224	1.208	1.216

Table A.11 Initial and zeroed readings for wax lubricant test 1 (continued)

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
116.78	0.192	0.805	0.850	116.66	1.185	1.225	1.208	1.216
117.78	0.192	0.805	0.849	117.66	1.185	1.225	1.209	1.217
127.91	0.172	0.789	0.833	127.78	1.205	1.241	1.226	1.233
139.13	0.172	0.785	0.832	139.01	1.205	1.245	1.226	1.235
110.36	0.145	0.763	0.809	110.24	1.232	1.267	1.249	1.258
122.04	0.120	0.742	0.790	121.92	1.257	1.288	1.269	1.278
112.79	0.094	0.713	0.764	112.67	1.283	1.317	1.295	1.306
114.06	0.070	0.698	0.742	113.94	1.307	1.331	1.316	1.324
113.19	0.046	0.679	0.721	113.06	1.331	1.351	1.337	1.344
112.23	0.021	0.656	0.699	112.11	1.356	1.373	1.359	1.366
111.25	-0.007	0.636	0.677	111.13	1.384	1.393	1.382	1.387
105.68	-0.028	0.618	0.661	105.56	1.405	1.412	1.397	1.404
108.59	-0.030	0.618	0.659	108.47	1.407	1.412	1.399	1.405
108.53	-0.032	0.615	0.658	108.41	1.409	1.415	1.400	1.407
110.11	-0.033	0.614	0.657	109.99	1.410	1.415	1.402	1.409
110.65	-0.033	0.614	0.656	110.53	1.410	1.415	1.403	1.409
111.55	-0.033	0.614	0.654	111.42	1.410	1.415	1.404	1.410
112.23	-0.034	0.614	0.654	112.11	1.411	1.416	1.404	1.410
113.48	-0.034	0.614	0.654	113.35	1.411	1.416	1.404	1.410
114.60	-0.055	0.597	0.638	114.48	1.432	1.432	1.420	1.426
114.25	-0.079	0.577	0.619	114.12	1.456	1.453	1.439	1.446
108.66	-0.104	0.557	0.598	108.53	1.480	1.472	1.461	1.466
110.42	-0.128	0.536	0.577	110.30	1.504	1.494	1.481	1.488
111.86	-0.151	0.516	0.558	111.73	1.528	1.514	1.501	1.507
111.82	-0.176	0.497	0.542	111.69	1.553	1.533	1.517	1.525
111.96	-0.203	0.473	0.516	111.84	1.579	1.556	1.542	1.549
109.57	-0.231	0.449	0.493	109.45	1.608	1.580	1.565	1.573
100.82	-0.261	0.426	0.468	100.69	1.638	1.604	1.590	1.597
101.75	-0.266	0.421	0.465	101.63	1.643	1.608	1.593	1.601
101.46	-0.268	0.419	0.464	101.34	1.645	1.611	1.594	1.602
102.11	-0.269	0.418	0.464	101.98	1.646	1.611	1.594	1.603
102.75	-0.270	0.418	0.464	102.63	1.647	1.612	1.595	1.603
104.00	-0.271	0.418	0.462	103.87	1.648	1.612	1.596	1.604
105.02	-0.271	0.418	0.461	104.89	1.648	1.612	1.597	1.604
105.54	-0.272	0.418	0.461	105.41	1.649	1.612	1.597	1.605
106.39	-0.272	0.418	0.461	106.26	1.649	1.612	1.598	1.605
116.12	-0.277	0.409	0.457	115.99	1.654	1.621	1.601	1.611
98.41	-0.300	0.390	0.438	98.28	1.677	1.640	1.621	1.630
106.33	-0.321	0.370	0.421	106.20	1.698	1.659	1.637	1.648
102.15	-0.343	0.351	0.405	102.02	1.720	1.679	1.654	1.666
105.31	-0.364	0.332	0.382	105.18	1.741	1.698	1.676	1.687
104.12	-0.385	0.313	0.367	104.00	1.762	1.717	1.691	1.704
99.61	-0.405	0.294	0.347	99.49	1.782	1.736	1.711	1.724

Table A.11 Initial and zeroed readings for wax lubricant test 1 (continued)

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
101.48	-0.425	0.273	0.327	101.36	1.802	1.757	1.731	1.744
102.17	-0.445	0.258	0.309	102.04	1.822	1.771	1.750	1.761
101.94	-0.466	0.238	0.289	101.82	1.843	1.792	1.769	1.780
92.48	-0.480	0.222	0.277	92.36	1.857	1.808	1.781	1.795
93.98	-0.482	0.223	0.273	93.85	1.859	1.807	1.785	1.796
94.48	-0.484	0.222	0.273	94.35	1.861	1.808	1.786	1.797
94.60	-0.485	0.219	0.273	94.48	1.862	1.811	1.785	1.798
95.60	-0.485	0.218	0.273	95.47	1.862	1.811	1.785	1.798
96.31	-0.485	0.218	0.273	96.18	1.862	1.811	1.785	1.798
97.10	-0.486	0.218	0.273	96.97	1.863	1.812	1.786	1.799
98.07	-0.486	0.218	0.272	97.95	1.863	1.811	1.787	1.799
125.43	-0.486	0.219	0.270	125.31	1.863	1.811	1.788	1.800
105.29	-0.509	0.194	0.248	105.16	1.886	1.836	1.810	1.823
100.30	-0.532	0.175	0.236	100.17	1.909	1.855	1.823	1.839
105.47	-0.554	0.153	0.208	105.35	1.931	1.877	1.850	1.864
103.58	-0.577	0.132	0.194	103.46	1.954	1.898	1.865	1.881
98.93	-0.599	0.112	0.170	98.80	1.976	1.917	1.889	1.903
99.42	-0.620	0.092	0.146	99.30	1.997	1.938	1.913	1.925
100.84	-0.643	0.069	0.125	100.71	2.020	1.961	1.934	1.947
96.60	-0.666	0.045	0.102	96.47	2.043	1.985	1.956	1.970
94.79	-0.677	0.038	0.093	94.66	2.054	1.992	1.965	1.978
93.58	-0.679	0.034	0.091	93.46	2.056	1.996	1.967	1.982
93.98	-0.681	0.034	0.089	93.85	2.058	1.996	1.970	1.983
95.12	-0.681	0.034	0.089	95.00	2.058	1.996	1.969	1.982
96.26	-0.682	0.034	0.089	96.14	2.059	1.996	1.969	1.982
97.18	-0.682	0.032	0.089	97.05	2.059	1.998	1.969	1.983
97.87	-0.683	0.030	0.089	97.74	2.060	1.999	1.969	1.984

Table A.12 Initial and zeroed readings for wax lubricant test 2

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
0.17	1.954	2.111	2.105	0.00	0.000	0.000	0.000	0.000
0.26	1.945	2.111	2.106	0.10	0.010	0.000	0.000	0.000
0.18	1.954	2.111	2.105	0.02	0.000	0.000	0.000	0.000
0.65	1.954	2.111	2.105	0.48	0.000	0.000	0.000	0.000
0.35	1.954	2.111	2.105	0.19	0.000	0.000	0.000	0.000
0.55	1.954	2.111	2.105	0.38	0.000	0.001	0.000	0.000
0.23	1.954	2.111	2.105	0.07	0.000	0.000	0.000	0.000
0.88	1.954	2.111	2.105	0.72	0.000	0.001	0.000	0.000
0.83	1.954	2.111	2.106	0.67	0.000	0.001	0.000	0.000
0.41	1.954	2.082	2.105	0.25	0.000	0.030	0.000	0.015
9.94	1.954	2.085	2.105	9.78	0.000	0.026	0.000	0.013
97.49	1.953	2.102	2.096	97.33	0.001	0.009	0.010	0.010
58.86	1.939	2.071	2.053	58.70	0.015	0.040	0.052	0.046
63.50	1.927	2.056	2.037	63.33	0.028	0.056	0.069	0.062
58.66	1.912	2.033	2.018	58.49	0.042	0.078	0.087	0.083
60.30	1.898	2.011	1.990	60.13	0.057	0.101	0.115	0.108
42.94	1.884	1.982	1.980	42.77	0.070	0.130	0.125	0.127
55.99	1.882	1.985	1.976	55.83	0.072	0.126	0.130	0.128
55.54	1.881	1.986	1.977	55.37	0.073	0.125	0.129	0.127
55.29	1.880	1.986	1.976	55.12	0.074	0.126	0.129	0.127
55.64	1.880	1.986	1.973	55.48	0.075	0.126	0.132	0.129
56.04	1.879	1.982	1.972	55.87	0.075	0.129	0.134	0.132
56.20	1.879	1.980	1.974	56.04	0.076	0.132	0.132	0.132
56.43	1.879	1.982	1.973	56.27	0.076	0.130	0.133	0.131
56.70	1.878	1.982	1.973	56.54	0.076	0.129	0.133	0.131
59.05	1.878	1.982	1.973	58.89	0.076	0.129	0.132	0.131
81.34	1.866	1.951	1.956	81.17	0.088	0.160	0.149	0.155
71.19	1.848	1.938	1.933	71.03	0.107	0.173	0.172	0.173
74.14	1.829	1.915	1.909	73.98	0.125	0.197	0.196	0.197
73.92	1.811	1.886	1.886	73.75	0.143	0.226	0.220	0.223
75.74	1.794	1.871	1.867	75.58	0.161	0.241	0.239	0.240
78.74	1.776	1.850	1.848	78.57	0.178	0.262	0.257	0.260
80.57	1.758	1.834	1.822	80.40	0.196	0.277	0.283	0.280
80.36	1.740	1.804	1.802	80.20	0.215	0.308	0.303	0.306
75.81	1.731	1.799	1.794	75.64	0.224	0.312	0.311	0.312
73.87	1.729	1.793	1.793	73.71	0.226	0.318	0.313	0.316
73.15	1.728	1.794	1.791	72.98	0.227	0.318	0.314	0.316
73.50	1.727	1.791	1.790	73.33	0.228	0.320	0.315	0.318
73.27	1.726	1.794	1.790	73.11	0.228	0.317	0.315	0.316
73.52	1.726	1.789	1.789	73.36	0.229	0.322	0.316	0.319
73.89	1.725	1.790	1.789	73.73	0.229	0.321	0.316	0.319
74.10	1.725	1.792	1.787	73.94	0.229	0.320	0.319	0.319
101.75	1.723	1.788	1.779	101.59	0.232	0.324	0.326	0.325

Table A.12 Initial and zeroed readings for wax lubricant test 2 (continued)

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
77.60	1.705	1.764	1.763	77.43	0.249	0.348	0.342	0.345
82.19	1.688	1.748	1.744	82.02	0.267	0.363	0.362	0.362
81.92	1.669	1.719	1.724	81.75	0.285	0.392	0.382	0.387
85.25	1.652	1.706	1.702	85.08	0.303	0.405	0.403	0.404
81.90	1.633	1.687	1.678	81.73	0.321	0.424	0.428	0.426
83.37	1.615	1.663	1.662	83.21	0.340	0.448	0.443	0.446
82.23	1.595	1.642	1.637	82.07	0.359	0.469	0.468	0.469
83.40	1.574	1.617	1.617	83.23	0.380	0.495	0.489	0.492
76.66	1.568	1.612	1.610	76.49	0.387	0.499	0.496	0.497
75.23	1.565	1.609	1.607	75.06	0.389	0.503	0.498	0.500
74.91	1.564	1.608	1.606	74.75	0.390	0.503	0.499	0.501
75.10	1.563	1.604	1.604	74.94	0.391	0.507	0.502	0.504
75.33	1.563	1.605	1.604	75.16	0.392	0.507	0.502	0.504
75.89	1.562	1.604	1.603	75.73	0.392	0.507	0.502	0.505
76.29	1.562	1.605	1.603	76.12	0.392	0.507	0.502	0.504
76.76	1.562	1.605	1.603	76.60	0.393	0.506	0.503	0.504
73.42	1.552	1.592	1.591	73.25	0.403	0.519	0.514	0.517
85.79	1.534	1.566	1.568	85.62	0.421	0.545	0.538	0.541
91.36	1.515	1.550	1.549	91.19	0.439	0.561	0.556	0.559
84.87	1.497	1.530	1.528	84.71	0.458	0.581	0.577	0.579
86.47	1.480	1.511	1.510	86.31	0.474	0.600	0.595	0.597
85.66	1.465	1.492	1.491	85.50	0.490	0.619	0.615	0.617
85.18	1.448	1.472	1.475	85.02	0.506	0.639	0.631	0.635
83.58	1.431	1.452	1.455	83.42	0.523	0.659	0.651	0.655
83.81	1.415	1.435	1.435	83.65	0.540	0.677	0.670	0.674
73.50	1.403	1.421	1.423	73.33	0.552	0.690	0.682	0.686
75.72	1.401	1.417	1.420	75.56	0.554	0.694	0.686	0.690
75.23	1.399	1.418	1.420	75.06	0.555	0.693	0.685	0.689
74.77	1.398	1.416	1.418	74.60	0.556	0.695	0.687	0.691
75.04	1.398	1.416	1.416	74.87	0.557	0.695	0.689	0.692
75.39	1.397	1.414	1.416	75.23	0.557	0.697	0.689	0.693
75.79	1.397	1.413	1.416	75.62	0.557	0.698	0.689	0.694
75.91	1.397	1.413	1.416	75.75	0.558	0.698	0.690	0.694
77.53	1.397	1.413	1.416	77.37	0.558	0.698	0.689	0.694
93.35	1.384	1.398	1.400	93.19	0.571	0.714	0.705	0.709
90.32	1.367	1.379	1.381	90.15	0.588	0.733	0.725	0.729
87.57	1.350	1.357	1.361	87.41	0.605	0.754	0.744	0.749
87.97	1.333	1.338	1.343	87.80	0.622	0.773	0.763	0.768
88.61	1.314	1.317	1.320	88.45	0.641	0.795	0.785	0.790
86.45	1.295	1.296	1.300	86.29	0.659	0.815	0.805	0.810
90.21	1.275	1.260	1.277	90.05	0.679	0.851	0.829	0.840
87.20	1.254	1.239	1.253	87.03	0.701	0.872	0.853	0.862
74.46	1.238	1.226	1.236	74.29	0.716	0.886	0.869	0.877

Table A.12 Initial and zeroed readings for wax lubricant test 2 (continued)

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
78.28	1.236	1.207	1.233	78.12	0.719	0.904	0.873	0.889
78.63	1.234	1.221	1.232	78.47	0.720	0.890	0.873	0.882
78.61	1.233	1.220	1.229	78.45	0.721	0.891	0.877	0.884
78.99	1.233	1.219	1.229	78.82	0.722	0.892	0.876	0.884
79.47	1.232	1.086	1.229	79.30	0.722	1.025	0.877	0.951
79.55	1.232	1.192	1.229	79.38	0.723	0.919	0.877	0.898
80.03	1.231	1.205	1.229	79.86	0.723	0.906	0.877	0.892
100.90	1.227	1.183	1.220	100.74	0.728	0.928	0.885	0.907
79.07	1.207	1.164	1.198	78.91	0.748	0.948	0.907	0.927
89.01	1.188	1.143	1.179	88.84	0.766	0.969	0.927	0.948
86.62	1.169	1.146	1.154	86.45	0.786	0.965	0.951	0.958
87.68	1.151	1.046	1.137	87.51	0.804	1.065	0.968	1.017
87.72	1.133	1.050	1.117	87.55	0.821	1.061	0.988	1.025
89.45	1.116	1.090	1.099	89.28	0.839	1.021	1.006	1.014
85.74	1.095	1.054	1.078	85.58	0.859	1.058	1.028	1.043
83.79	1.075	1.039	1.055	83.63	0.880	1.073	1.050	1.061
78.57	1.065	1.030	1.046	78.41	0.890	1.081	1.060	1.071
76.60	1.062	1.028	1.042	76.43	0.892	1.083	1.063	1.073
75.99	1.061	1.015	1.042	75.83	0.893	1.096	1.063	1.080
76.08	1.060	1.023	1.042	75.91	0.894	1.089	1.064	1.076
76.33	1.060	1.023	1.040	76.16	0.895	1.088	1.066	1.077
76.58	1.059	1.023	1.039	76.41	0.895	1.089	1.067	1.078
76.76	1.059	1.020	1.039	76.60	0.896	1.092	1.067	1.079
89.86	1.058	1.021	1.038	89.70	0.896	1.091	1.067	1.079
112.52	1.058	1.014	1.038	112.36	0.897	1.097	1.067	1.082
90.15	1.038	0.999	1.017	89.99	0.917	1.113	1.089	1.101
81.05	1.015	0.972	0.994	80.88	0.940	1.139	1.111	1.125
87.37	0.993	0.951	0.972	87.20	0.961	1.160	1.133	1.147
86.33	0.972	0.928	0.951	86.16	0.982	1.183	1.154	1.169
83.56	0.951	0.904	0.930	83.40	1.004	1.207	1.176	1.191
88.53	0.929	0.882	0.908	88.37	1.025	1.229	1.197	1.213
86.06	0.908	0.860	0.888	85.89	1.046	1.252	1.218	1.235
86.93	0.889	0.840	0.868	86.76	1.065	1.271	1.238	1.254
81.34	0.880	0.832	0.859	81.17	1.074	1.279	1.246	1.263
80.24	0.878	0.832	0.858	80.07	1.077	1.280	1.247	1.264
80.26	0.876	0.828	0.855	80.09	1.078	1.283	1.250	1.267
80.67	0.875	0.828	0.856	80.51	1.079	1.283	1.250	1.267
80.57	0.875	0.828	0.856	80.40	1.080	1.283	1.250	1.267
80.40	0.874	0.828	0.855	80.24	1.080	1.283	1.250	1.267
80.63	0.874	0.829	0.854	80.47	1.081	1.283	1.252	1.267
118.24	0.872	0.824	0.852	118.07	1.082	1.287	1.253	1.270
89.72	0.847	0.800	0.829	89.55	1.107	1.312	1.277	1.294
89.61	0.822	0.774	0.807	89.45	1.132	1.337	1.299	1.318

Table A.12 Initial and zeroed readings for wax lubricant test 2 (continued)

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
90.71	0.798	0.751	0.783	90.55	1.156	1.360	1.323	1.342
90.28	0.777	0.724	0.760	90.11	1.178	1.388	1.346	1.367
87.51	0.757	0.708	0.743	87.35	1.197	1.404	1.363	1.383
89.53	0.740	0.691	0.724	89.36	1.215	1.420	1.381	1.401
87.95	0.722	0.673	0.707	87.78	1.232	1.438	1.398	1.418
88.20	0.703	0.653	0.688	88.03	1.251	1.458	1.418	1.438
75.16	0.686	0.637	0.671	75.00	1.269	1.474	1.434	1.454
81.19	0.683	0.637	0.672	81.03	1.271	1.474	1.433	1.454
81.94	0.682	0.634	0.669	81.78	1.272	1.478	1.436	1.457
82.02	0.681	0.634	0.668	81.86	1.274	1.478	1.438	1.458
82.15	0.680	0.634	0.668	81.98	1.274	1.478	1.438	1.458
82.61	0.680	0.634	0.668	82.44	1.275	1.478	1.437	1.457
83.42	0.680	0.633	0.666	83.25	1.275	1.479	1.439	1.459
84.00	0.679	0.633	0.668	83.83	1.275	1.479	1.438	1.458
76.74	0.663	0.614	0.651	76.58	1.292	1.497	1.455	1.476
100.13	0.643	0.596	0.635	99.97	1.311	1.515	1.471	1.493
91.05	0.621	0.576	0.611	90.88	1.333	1.536	1.494	1.515
92.31	0.601	0.556	0.594	92.15	1.353	1.555	1.511	1.533
91.88	0.583	0.536	0.576	91.71	1.372	1.575	1.529	1.552
91.23	0.563	0.518	0.557	91.07	1.391	1.593	1.548	1.570
93.06	0.544	0.501	0.539	92.90	1.411	1.611	1.566	1.588
94.41	0.522	0.478	0.518	94.25	1.433	1.633	1.588	1.611
94.14	0.500	0.458	0.498	93.98	1.454	1.654	1.607	1.630
82.02	0.484	0.445	0.483	81.86	1.471	1.667	1.623	1.645
86.93	0.482	0.442	0.483	86.76	1.473	1.669	1.623	1.646
87.53	0.480	0.441	0.480	87.37	1.474	1.670	1.625	1.648
88.07	0.479	0.441	0.479	87.91	1.475	1.670	1.626	1.648
88.51	0.479	0.438	0.479	88.34	1.476	1.673	1.626	1.650
88.70	0.478	0.438	0.478	88.53	1.477	1.674	1.627	1.650
89.05	0.478	0.438	0.478	88.89	1.477	1.674	1.627	1.650
89.63	0.477	0.438	0.477	89.47	1.477	1.673	1.629	1.651
125.85	0.476	0.437	0.476	125.68	1.478	1.674	1.629	1.652
98.11	0.454	0.417	0.456	97.95	1.500	1.695	1.649	1.672
95.35	0.434	0.399	0.441	95.18	1.520	1.713	1.665	1.689
98.39	0.415	0.380	0.421	98.22	1.539	1.732	1.684	1.708
94.75	0.395	0.361	0.406	94.58	1.559	1.751	1.700	1.725
94.04	0.374	0.340	0.386	93.87	1.581	1.771	1.719	1.745
94.29	0.352	0.320	0.368	94.12	1.603	1.791	1.737	1.764
94.06	0.328	0.299	0.347	93.90	1.627	1.812	1.758	1.785
95.12	0.301	0.277	0.324	94.96	1.653	1.835	1.781	1.808
91.44	0.278	0.254	0.303	91.28	1.676	1.857	1.802	1.830
87.39	0.269	0.246	0.296	87.22	1.685	1.865	1.810	1.838
86.56	0.267	0.246	0.293	86.39	1.688	1.865	1.812	1.839

Table A.12 Initial and zeroed readings for wax lubricant test 2 (continued)

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
86.47	0.266	0.244	0.292	86.31	1.689	1.868	1.813	1.840
86.93	0.264	0.242	0.292	86.76	1.690	1.869	1.814	1.841
87.28	0.264	0.241	0.291	87.12	1.691	1.870	1.814	1.842
87.93	0.263	0.243	0.290	87.76	1.691	1.869	1.815	1.842
88.36	0.263	0.243	0.290	88.20	1.691	1.869	1.816	1.842
105.54	0.262	0.243	0.290	105.37	1.692	1.869	1.816	1.842
121.57	0.262	0.241	0.288	121.40	1.693	1.870	1.817	1.843
96.18	0.242	0.222	0.275	96.02	1.713	1.889	1.830	1.860
93.54	0.220	0.202	0.253	93.38	1.734	1.909	1.852	1.881
97.22	0.200	0.182	0.237	97.06	1.755	1.929	1.869	1.899
99.40	0.178	0.167	0.221	99.24	1.776	1.944	1.884	1.914
100.53	0.157	0.147	0.201	100.36	1.798	1.964	1.904	1.934
99.42	0.134	0.127	0.181	99.26	1.821	1.984	1.925	1.954
98.86	0.108	0.104	0.158	98.70	1.846	2.007	1.947	1.977
100.55	0.082	0.083	0.138	100.38	1.872	2.028	1.967	1.998
96.22	0.054	0.057	0.113	96.06	1.900	2.054	1.992	2.023
89.45	0.047	0.053	0.107	89.28	1.907	2.058	1.999	2.028
88.72	0.045	0.053	0.105	88.55	1.909	2.058	2.001	2.030
88.86	0.044	0.050	0.105	88.70	1.911	2.062	2.000	2.031
89.45	0.043	0.050	0.102	89.28	1.911	2.062	2.003	2.032
89.99	0.042	0.050	0.101	89.82	1.912	2.061	2.005	2.033
90.44	0.042	0.050	0.101	90.28	1.913	2.062	2.004	2.033
90.86	0.042	0.049	0.101	90.69	1.913	2.062	2.004	2.033
125.66	0.039	0.046	0.098	125.50	1.915	2.065	2.007	2.036
94.91	0.013	0.021	0.078	94.75	1.942	2.090	2.027	2.059
97.41	-0.014	0.014	0.055	97.24	1.968	2.098	2.050	2.074
98.99	-0.040	0.013	0.035	98.82	1.995	2.098	2.070	2.084
97.72	-0.067	0.013	0.015	97.55	2.022	2.098	2.090	2.094
98.90	-0.092	0.013	0.004	98.74	2.047	2.098	2.101	2.100
100.42	-0.115	0.013	0.003	100.26	2.069	2.098	2.102	2.100
101.92	-0.140	0.013	0.003	101.75	2.095	2.098	2.102	2.100
100.28	-0.168	0.013	0.004	100.11	2.122	2.099	2.102	2.100
89.47	-0.188	0.013	0.003	89.30	2.143	2.098	2.102	2.100
90.96	-0.191	0.013	0.003	90.80	2.146	2.098	2.102	2.100

Table A.13 Initial and zeroed readings for wax lubricant test 3

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
0.16	1.624	2.058	1.681	0.00	0.000	0.000	0.000	0.000
0.25	1.623	2.058	1.681	0.09	0.000	0.000	0.000	0.000
0.17	1.623	2.057	1.681	0.02	0.000	0.000	0.000	0.000
0.33	1.623	2.058	1.681	0.17	0.000	0.000	0.000	0.000
0.79	1.623	2.057	1.681	0.64	0.000	0.000	0.000	0.000
0.87	1.623	2.057	1.681	0.72	0.000	0.001	0.000	0.000
0.27	1.623	2.057	1.681	0.12	0.000	0.001	0.000	0.000
0.18	1.623	2.058	1.681	0.02	0.000	0.000	0.000	0.000
9.20	1.623	2.057	1.681	9.04	0.000	0.001	0.000	0.000
21.80	1.622	2.053	1.675	21.64	0.001	0.004	0.006	0.005
34.79	1.620	2.046	1.665	34.63	0.004	0.012	0.016	0.014
40.07	1.608	2.034	1.650	39.91	0.016	0.024	0.031	0.027
39.94	1.595	2.018	1.635	39.79	0.029	0.040	0.046	0.043
45.35	1.581	1.996	1.618	45.19	0.042	0.061	0.063	0.062
42.63	1.566	1.981	1.602	42.47	0.058	0.077	0.079	0.078
43.25	1.548	1.955	1.583	43.10	0.076	0.102	0.098	0.100
39.61	1.541	1.947	1.576	39.46	0.083	0.111	0.105	0.108
39.74	1.539	1.952	1.575	39.58	0.085	0.105	0.106	0.106
39.97	1.538	1.917	1.573	39.81	0.086	0.141	0.108	0.124
40.26	1.537	1.945	1.573	40.10	0.087	0.113	0.108	0.110
40.55	1.536	1.946	1.572	40.39	0.087	0.112	0.109	0.110
40.63	1.536	1.947	1.571	40.48	0.088	0.110	0.110	0.110
41.13	1.536	1.948	1.571	40.97	0.088	0.110	0.110	0.110
41.61	1.536	1.946	1.571	41.45	0.088	0.112	0.110	0.111
43.56	1.529	1.930	1.561	43.41	0.095	0.127	0.120	0.124
43.44	1.515	1.918	1.545	43.28	0.109	0.140	0.136	0.138
53.56	1.501	1.905	1.530	53.41	0.123	0.152	0.151	0.152
51.65	1.486	1.881	1.514	51.49	0.138	0.177	0.167	0.172
55.35	1.471	1.869	1.497	55.19	0.153	0.189	0.184	0.186
57.18	1.457	1.854	1.482	57.02	0.167	0.204	0.199	0.201
58.86	1.443	1.837	1.467	58.71	0.180	0.221	0.214	0.218
58.63	1.442	1.834	1.464	58.48	0.182	0.224	0.217	0.221
60.69	1.428	1.816	1.449	60.54	0.196	0.242	0.232	0.237
60.03	1.414	1.802	1.431	59.87	0.210	0.255	0.250	0.253
62.17	1.400	1.786	1.416	62.01	0.224	0.271	0.265	0.268
62.13	1.385	1.762	1.400	61.97	0.239	0.295	0.281	0.288
55.10	1.377	1.759	1.390	54.95	0.247	0.298	0.291	0.295
54.19	1.375	1.748	1.389	54.03	0.248	0.309	0.292	0.301
54.04	1.374	1.757	1.389	53.89	0.250	0.301	0.292	0.297
54.29	1.373	1.756	1.386	54.13	0.250	0.302	0.295	0.299
54.31	1.373	1.755	1.386	54.16	0.251	0.302	0.295	0.299
54.33	1.372	1.755	1.385	54.18	0.251	0.303	0.296	0.300
54.54	1.372	1.755	1.385	54.38	0.251	0.302	0.296	0.299

Table A.13 Initial and zeroed readings for wax lubricant test 3 (continued)

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
54.71	1.372	1.755	1.385	54.55	0.252	0.302	0.296	0.299
62.52	1.372	1.753	1.386	62.37	0.252	0.304	0.295	0.300
73.52	1.359	1.739	1.370	73.37	0.265	0.319	0.311	0.315
64.48	1.342	1.721	1.350	64.32	0.281	0.337	0.331	0.334
65.45	1.327	1.702	1.332	65.30	0.297	0.356	0.349	0.352
68.30	1.312	1.686	1.315	68.15	0.312	0.371	0.366	0.368
66.87	1.298	1.671	1.299	66.71	0.326	0.387	0.382	0.384
69.15	1.285	1.655	1.284	69.00	0.339	0.403	0.397	0.400
72.13	1.271	1.640	1.268	71.97	0.353	0.417	0.413	0.415
70.76	1.256	1.624	1.252	70.60	0.368	0.433	0.429	0.431
73.85	1.240	1.605	1.233	73.70	0.383	0.452	0.448	0.450
74.00	1.224	1.588	1.214	73.84	0.399	0.469	0.467	0.468
68.18	1.213	1.573	1.202	68.02	0.411	0.484	0.479	0.482
69.63	1.211	1.573	1.198	69.48	0.413	0.484	0.483	0.484
70.13	1.210	1.568	1.198	69.98	0.414	0.489	0.483	0.486
69.90	1.208	1.569	1.198	69.75	0.415	0.489	0.483	0.486
70.24	1.209	1.569	1.198	70.08	0.415	0.488	0.483	0.485
70.40	1.208	1.570	1.196	70.25	0.416	0.488	0.485	0.487
70.49	1.208	1.569	1.195	70.33	0.416	0.489	0.486	0.487
70.96	1.208	1.569	1.195	70.81	0.416	0.489	0.486	0.487
86.95	1.208	1.568	1.194	86.80	0.416	0.489	0.487	0.488
86.91	1.192	1.550	1.176	86.75	0.432	0.508	0.505	0.506
77.99	1.173	1.526	1.152	77.84	0.451	0.532	0.529	0.530
83.69	1.154	1.508	1.133	83.53	0.469	0.549	0.548	0.549
82.42	1.137	1.488	1.114	82.26	0.487	0.570	0.567	0.569
84.58	1.119	1.468	1.094	84.43	0.504	0.590	0.587	0.588
83.89	1.102	1.449	1.076	83.74	0.521	0.608	0.605	0.607
87.28	1.085	1.431	1.057	87.13	0.539	0.626	0.624	0.625
86.08	1.067	1.412	1.036	85.92	0.557	0.646	0.645	0.645
86.16	1.047	1.390	1.013	86.01	0.576	0.668	0.668	0.668
77.60	1.040	1.382	1.008	77.44	0.583	0.676	0.673	0.674
75.97	1.038	1.381	1.007	75.82	0.586	0.676	0.674	0.675
76.08	1.037	1.381	1.006	75.92	0.587	0.676	0.675	0.676
76.56	1.036	1.378	1.003	76.40	0.588	0.680	0.678	0.679
76.85	1.035	1.377	1.003	76.69	0.588	0.680	0.678	0.679
76.97	1.035	1.377	1.003	76.82	0.589	0.681	0.678	0.679
77.08	1.035	1.378	1.004	76.92	0.589	0.680	0.677	0.679
77.70	1.035	1.377	1.003	77.54	0.589	0.681	0.678	0.679
79.88	1.018	1.361	0.984	79.73	0.605	0.697	0.697	0.697
94.21	1.018	1.358	0.984	94.05	0.606	0.700	0.697	0.698
101.13	1.017	1.359	0.979	100.97	0.607	0.699	0.702	0.700
84.19	0.994	1.335	0.958	84.03	0.630	0.723	0.723	0.723
89.05	0.972	1.313	0.935	88.90	0.651	0.745	0.746	0.745

Table A.13 Initial and zeroed readings for wax lubricant test 3 (continued)

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
91.13	0.950	1.290	0.913	90.97	0.674	0.768	0.768	0.768
91.36	0.928	1.267	0.889	91.20	0.695	0.791	0.792	0.791
89.92	0.907	1.244	0.869	89.77	0.716	0.814	0.812	0.813
92.36	0.886	1.223	0.848	92.20	0.738	0.835	0.833	0.834
88.18	0.862	1.196	0.825	88.02	0.761	0.862	0.856	0.859
80.69	0.853	1.185	0.817	80.54	0.771	0.873	0.864	0.868
80.36	0.851	1.179	0.813	80.21	0.773	0.878	0.868	0.873
80.36	0.849	1.115	0.813	80.21	0.774	0.942	0.868	0.905
81.09	0.849	1.103	0.814	80.93	0.775	0.955	0.867	0.911
81.79	0.848	1.179	0.814	81.64	0.776	0.878	0.867	0.873
82.13	0.848	1.179	0.812	81.97	0.776	0.879	0.869	0.874
82.69	0.847	1.177	0.812	82.53	0.776	0.881	0.869	0.875
83.37	0.847	1.179	0.810	83.22	0.776	0.878	0.871	0.875
127.18	0.847	1.179	0.809	127.02	0.777	0.879	0.872	0.875
94.73	0.822	1.165	0.785	94.57	0.802	0.893	0.896	0.895
87.57	0.798	1.137	0.760	87.42	0.826	0.921	0.921	0.921
89.18	0.774	1.113	0.737	89.02	0.850	0.945	0.944	0.944
87.12	0.751	1.079	0.714	86.96	0.873	0.979	0.967	0.973
89.69	0.728	1.070	0.692	89.54	0.895	0.988	0.989	0.989
87.55	0.706	1.046	0.668	87.40	0.918	1.012	1.013	1.012
87.66	0.683	0.985	0.648	87.50	0.941	1.073	1.033	1.053
84.87	0.661	1.005	0.627	84.72	0.962	1.053	1.054	1.053
77.89	0.654	0.999	0.621	77.73	0.969	1.059	1.060	1.059
77.26	0.652	0.997	0.619	77.11	0.972	1.061	1.062	1.061
76.87	0.651	0.994	0.619	76.71	0.972	1.063	1.062	1.063
76.72	0.650	0.995	0.617	76.57	0.973	1.063	1.064	1.063
77.16	0.649	0.994	0.615	77.00	0.974	1.063	1.066	1.064
77.64	0.649	0.993	0.615	77.48	0.975	1.064	1.066	1.065
78.68	0.649	0.995	0.615	78.52	0.975	1.063	1.066	1.064
79.94	0.649	0.993	0.615	79.79	0.975	1.064	1.066	1.065
117.57	0.648	0.991	0.615	117.42	0.976	1.067	1.066	1.066
89.90	0.625	0.969	0.591	89.75	0.998	1.089	1.090	1.089
83.04	0.603	0.943	0.569	82.89	1.021	1.115	1.112	1.113
87.70	0.580	0.927	0.548	87.54	1.044	1.131	1.133	1.132
84.31	0.555	0.905	0.522	84.16	1.069	1.153	1.159	1.156
89.09	0.530	0.880	0.500	88.94	1.093	1.178	1.181	1.179
86.41	0.505	0.858	0.476	86.25	1.119	1.200	1.205	1.202
89.72	0.480	0.835	0.455	89.56	1.143	1.222	1.226	1.224
82.75	0.456	0.813	0.439	82.60	1.168	1.245	1.242	1.243
78.32	0.449	0.808	0.428	78.17	1.175	1.249	1.253	1.251
78.55	0.447	0.806	0.426	78.40	1.177	1.252	1.255	1.253
78.88	0.446	0.805	0.425	78.73	1.178	1.252	1.256	1.254
78.76	0.445	0.804	0.422	78.60	1.179	1.254	1.259	1.256

Table A.13 Initial and zeroed readings for wax lubricant test 3 (continued)

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
78.82	0.444	0.804	0.422	78.67	1.180	1.254	1.259	1.257
79.03	0.443	0.803	0.421	78.87	1.180	1.254	1.260	1.257
79.53	0.443	0.801	0.421	79.37	1.180	1.256	1.260	1.258
80.24	0.443	0.801	0.421	80.08	1.181	1.257	1.260	1.259
99.74	0.443	0.801	0.421	99.58	1.181	1.257	1.260	1.258
116.33	0.442	0.801	0.421	116.17	1.182	1.256	1.260	1.258
90.71	0.416	0.778	0.395	90.56	1.208	1.279	1.286	1.282
89.76	0.390	0.755	0.374	89.60	1.233	1.303	1.307	1.305
89.55	0.363	0.726	0.351	89.39	1.261	1.331	1.330	1.331
87.55	0.336	0.700	0.324	87.40	1.287	1.357	1.357	1.357
89.84	0.309	0.685	0.302	89.69	1.314	1.373	1.379	1.376
90.71	0.285	0.661	0.279	90.56	1.338	1.397	1.402	1.399
91.59	0.262	0.642	0.259	91.43	1.361	1.415	1.422	1.419
88.01	0.243	0.627	0.244	87.86	1.380	1.431	1.437	1.434
81.88	0.236	0.618	0.240	81.72	1.387	1.439	1.441	1.440
81.79	0.234	0.618	0.236	81.64	1.389	1.440	1.445	1.442
82.07	0.233	0.617	0.234	81.91	1.391	1.440	1.447	1.443
82.38	0.232	0.614	0.234	82.22	1.391	1.443	1.447	1.445
82.88	0.232	0.615	0.234	82.72	1.392	1.443	1.447	1.445
83.15	0.231	0.614	0.235	82.99	1.392	1.443	1.446	1.445
83.46	0.231	0.614	0.235	83.30	1.393	1.443	1.446	1.445
83.77	0.230	0.614	0.234	83.61	1.393	1.443	1.447	1.445
121.84	0.230	0.613	0.239	121.68	1.394	1.445	1.442	1.443
89.92	0.205	0.591	0.212	89.77	1.419	1.467	1.469	1.468
84.19	0.179	0.573	0.192	84.03	1.445	1.485	1.489	1.487
86.35	0.156	0.550	0.165	86.19	1.468	1.508	1.516	1.512
89.57	0.134	0.532	0.146	89.41	1.490	1.526	1.535	1.530
92.31	0.113	0.513	0.129	92.16	1.511	1.544	1.552	1.548
92.56	0.090	0.493	0.109	92.41	1.533	1.565	1.572	1.569
89.38	0.065	0.472	0.085	89.23	1.558	1.586	1.596	1.591
92.88	0.040	0.449	0.063	92.72	1.584	1.608	1.618	1.613
76.18	0.016	0.430	0.044	76.03	1.608	1.628	1.637	1.633
87.35	0.013	0.426	0.042	87.19	1.610	1.631	1.639	1.635
87.26	0.011	0.426	0.042	87.11	1.612	1.632	1.639	1.635
87.16	0.010	0.422	0.040	87.00	1.613	1.636	1.641	1.638
87.72	0.009	0.423	0.039	87.56	1.614	1.635	1.642	1.639
88.20	0.009	0.422	0.039	88.04	1.615	1.635	1.642	1.639
88.30	0.008	0.421	0.038	88.15	1.615	1.636	1.643	1.639
88.41	0.008	0.421	0.038	88.25	1.616	1.636	1.643	1.640
118.09	0.008	0.422	0.039	117.94	1.616	1.636	1.642	1.639
122.29	0.006	0.418	0.037	122.14	1.617	1.639	1.644	1.642
96.33	-0.016	0.402	0.019	96.17	1.640	1.656	1.662	1.659
90.57	-0.034	0.386	0.007	90.41	1.657	1.672	1.674	1.673

Table A.13 Initial and zeroed readings for wax lubricant test 3 (continued)

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
92.07	-0.051	0.368	0.003	91.91	1.674	1.690	1.678	1.684
95.29	-0.068	0.358	0.003	95.13	1.691	1.699	1.678	1.689
94.33	-0.086	0.335	0.003	94.18	1.710	1.722	1.678	1.700
93.44	-0.105	0.326	0.004	93.28	1.729	1.732	1.677	1.705
92.73	-0.127	0.309	0.003	92.58	1.750	1.749	1.678	1.714
91.94	-0.150	0.293	0.004	91.79	1.773	1.764	1.677	1.721
95.45	-0.174	0.272	0.003	95.30	1.797	1.785	1.678	1.732
93.46	-0.199	0.253	0.004	93.30	1.822	1.805	1.677	1.741
72.94	-0.221	0.234	0.003	72.78	1.845	1.823	1.678	1.751
81.19	-0.224	0.233	0.003	81.04	1.847	1.824	1.678	1.751
80.05	-0.226	0.230	0.004	79.89	1.850	1.828	1.677	1.753
79.55	-0.227	0.230	0.003	79.39	1.851	1.827	1.678	1.752
79.92	-0.228	0.230	0.003	79.77	1.852	1.827	1.678	1.752
80.55	-0.229	0.228	0.004	80.39	1.852	1.830	1.677	1.754
81.36	-0.229	0.226	0.003	81.20	1.853	1.831	1.678	1.755
82.04	-0.230	0.226	0.003	81.89	1.853	1.832	1.678	1.755
104.87	-0.234	0.223	0.004	104.72	1.858	1.835	1.677	1.756
82.04	-0.262	0.200	0.003	81.89	1.886	1.857	1.678	1.768
86.60	-0.286	0.182	0.003	86.44	1.909	1.875	1.678	1.777
89.65	-0.310	0.162	0.004	89.50	1.934	1.896	1.677	1.787
93.02	-0.335	0.139	0.003	92.87	1.959	1.919	1.678	1.798
94.00	-0.362	0.116	0.003	93.84	1.986	1.941	1.678	1.810
90.71	-0.386	0.093	0.004	90.56	2.010	1.965	1.677	1.821
79.90	-0.398	0.081	0.003	79.75	2.022	1.977	1.678	1.827
79.49	-0.401	0.081	0.003	79.33	2.025	1.977	1.678	1.827
78.22	-0.403	0.077	0.003	78.06	2.026	1.981	1.678	1.830

Table A.14 Initial and zeroed readings for steel plate test 1

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
0.12	1.877	2.139	2.061	0.00	0.000	0.000	0.000	0.000
0.21	1.876	2.139	2.061	0.09	0.002	0.000	0.000	0.000
0.25	1.877	2.138	2.061	0.13	0.000	0.001	0.000	0.000
0.48	1.876	2.139	2.060	0.36	0.002	0.000	0.001	0.000
0.75	1.876	2.139	2.061	0.63	0.002	0.000	0.000	0.000
0.42	1.875	2.138	2.060	0.30	0.002	0.001	0.001	0.001
0.46	1.875	2.139	2.061	0.34	0.002	0.000	0.000	0.000
0.59	1.875	2.139	2.061	0.46	0.002	0.000	0.000	0.000
0.47	1.875	2.139	2.061	0.35	0.002	-0.001	0.000	0.000
0.46	1.875	2.139	2.061	0.34	0.002	0.000	0.000	0.000
3.38	1.875	2.138	2.061	3.25	0.002	0.001	0.000	0.001
29.90	1.875	2.138	2.060	29.78	0.002	0.001	0.001	0.001
60.98	1.875	2.139	2.058	60.86	0.002	0.000	0.003	0.002
102.04	1.873	2.139	2.056	101.92	0.004	0.000	0.005	0.003
85.37	1.873	2.134	2.036	85.25	0.005	0.005	0.025	0.015
81.84	1.863	2.130	2.019	81.71	0.014	0.009	0.042	0.026
77.26	1.851	2.119	2.009	77.14	0.027	0.020	0.052	0.036
78.36	1.841	2.103	1.993	78.24	0.036	0.036	0.068	0.052
75.43	1.829	2.092	1.980	75.31	0.048	0.047	0.081	0.064
72.38	1.818	2.081	1.968	72.26	0.059	0.058	0.093	0.076
73.40	1.806	2.071	1.957	73.27	0.071	0.068	0.104	0.086
76.39	1.797	2.047	1.946	76.27	0.081	0.092	0.115	0.103
79.67	1.786	2.051	1.932	79.55	0.091	0.088	0.129	0.108
80.13	1.776	2.036	1.916	80.01	0.102	0.103	0.145	0.124
76.29	1.773	2.037	1.917	76.16	0.105	0.102	0.144	0.123
79.76	1.772	2.036	1.917	79.64	0.105	0.102	0.144	0.123
80.30	1.772	2.034	1.917	80.18	0.105	0.105	0.144	0.125
80.86	1.771	2.033	1.914	80.74	0.106	0.106	0.147	0.127
81.50	1.772	2.033	1.917	81.38	0.105	0.106	0.144	0.125
82.15	1.771	2.033	1.915	82.03	0.106	0.106	0.146	0.126
82.79	1.771	2.033	1.913	82.67	0.107	0.106	0.148	0.127
83.42	1.770	2.033	1.913	83.29	0.108	0.106	0.148	0.127
84.08	1.771	2.033	1.913	83.96	0.106	0.106	0.148	0.127
84.71	1.771	2.033	1.914	84.58	0.106	0.106	0.147	0.126
91.40	1.770	2.033	1.914	91.28	0.107	0.106	0.147	0.127
85.37	1.760	2.021	1.905	85.25	0.118	0.118	0.156	0.137
85.20	1.748	2.010	1.890	85.08	0.130	0.129	0.171	0.150
85.33	1.736	1.984	1.869	85.21	0.141	0.155	0.192	0.173
80.46	1.721	1.976	1.860	80.34	0.156	0.163	0.201	0.182
76.60	1.704	1.962	1.841	76.48	0.173	0.177	0.220	0.198
77.43	1.673	1.947	1.824	77.31	0.204	0.192	0.237	0.214
78.39	1.631	1.932	1.813	78.26	0.246	0.207	0.248	0.228
78.95	1.599	1.916	1.796	78.82	0.278	0.223	0.265	0.244

Table A.14 Initial and zeroed readings for steel plate test 1 (continued)

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
77.43	1.580	1.900	1.779	77.31	0.297	0.239	0.282	0.261
76.22	1.564	1.882	1.759	76.10	0.313	0.257	0.302	0.280
76.31	1.549	1.864	1.742	76.18	0.329	0.275	0.320	0.297
67.53	1.536	1.850	1.728	67.41	0.342	0.289	0.333	0.311
82.09	1.535	1.851	1.727	81.96	0.342	0.288	0.334	0.311
82.54	1.535	1.850	1.726	82.42	0.343	0.289	0.335	0.312
84.58	1.533	1.850	1.726	84.46	0.344	0.289	0.335	0.312
86.64	1.533	1.850	1.727	86.52	0.344	0.289	0.334	0.312
88.26	1.533	1.849	1.725	88.14	0.344	0.290	0.336	0.313
89.72	1.532	1.845	1.722	89.59	0.345	0.294	0.339	0.316
91.07	1.533	1.846	1.723	90.95	0.345	0.293	0.338	0.316
92.27	1.533	1.845	1.723	92.15	0.345	0.294	0.338	0.316
93.40	1.532	1.846	1.723	93.27	0.346	0.293	0.338	0.315
94.37	1.533	1.845	1.723	94.25	0.345	0.294	0.338	0.316
53.29	1.523	1.829	1.711	53.17	0.354	0.310	0.350	0.330
77.72	1.517	1.830	1.708	77.60	0.360	0.309	0.353	0.331
70.76	1.505	1.820	1.691	70.63	0.372	0.319	0.370	0.345
77.72	1.489	1.798	1.677	77.60	0.388	0.341	0.384	0.363
84.46	1.473	1.780	1.651	84.33	0.404	0.359	0.410	0.384
76.47	1.456	1.756	1.637	76.35	0.421	0.383	0.424	0.404
76.70	1.440	1.738	1.615	76.58	0.437	0.401	0.446	0.424
75.85	1.422	1.714	1.598	75.73	0.455	0.425	0.463	0.444
72.11	1.404	1.701	1.579	71.98	0.473	0.438	0.482	0.460
67.91	1.387	1.678	1.560	67.79	0.491	0.461	0.501	0.481
58.76	1.370	1.659	1.540	58.64	0.507	0.480	0.521	0.500
63.56	1.367	1.658	1.540	63.44	0.511	0.481	0.521	0.501
64.10	1.365	1.655	1.536	63.98	0.512	0.484	0.525	0.505
64.91	1.364	1.655	1.537	64.79	0.513	0.484	0.524	0.504
65.52	1.365	1.655	1.536	65.39	0.513	0.484	0.525	0.504
65.99	1.364	1.656	1.536	65.87	0.514	0.483	0.525	0.504
66.49	1.364	1.656	1.536	66.37	0.513	0.483	0.525	0.504
66.93	1.364	1.655	1.535	66.81	0.514	0.484	0.526	0.505
67.35	1.363	1.655	1.536	67.22	0.514	0.484	0.525	0.505
67.78	1.363	1.655	1.532	67.66	0.514	0.484	0.529	0.506
47.91	1.355	1.642	1.524	47.79	0.522	0.497	0.537	0.517
58.59	1.345	1.631	1.513	58.47	0.532	0.508	0.548	0.528
75.56	1.336	1.616	1.502	75.44	0.542	0.523	0.560	0.541
90.73	1.324	1.597	1.486	90.61	0.553	0.542	0.575	0.559
92.21	1.309	1.581	1.469	92.09	0.568	0.558	0.592	0.575
85.93	1.292	1.561	1.450	85.81	0.585	0.578	0.611	0.594
82.63	1.275	1.542	1.431	82.50	0.602	0.597	0.630	0.614
82.15	1.256	1.521	1.410	82.03	0.622	0.618	0.651	0.634
86.18	1.237	1.499	1.388	86.06	0.640	0.640	0.673	0.656

Table A.14 Initial and zeroed readings for steel plate test 1 (continued)

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
83.62	1.217	1.476	1.364	83.50	0.661	0.663	0.697	0.680
86.47	1.206	1.467	1.355	86.35	0.671	0.672	0.706	0.689
86.31	1.204	1.463	1.353	86.18	0.673	0.676	0.708	0.692
87.70	1.203	1.463	1.351	87.58	0.674	0.676	0.710	0.693
88.61	1.203	1.462	1.350	88.49	0.675	0.677	0.711	0.694
89.69	1.202	1.463	1.350	89.57	0.675	0.676	0.711	0.693
90.57	1.202	1.463	1.350	90.45	0.675	0.676	0.711	0.693
91.25	1.202	1.463	1.350	91.13	0.676	0.676	0.711	0.694
92.21	1.201	1.463	1.349	92.09	0.676	0.676	0.712	0.694
92.79	1.201	1.463	1.349	92.67	0.676	0.676	0.712	0.694
131.73	1.201	1.462	1.349	131.61	0.676	0.677	0.712	0.695
104.87	1.187	1.444	1.331	104.75	0.691	0.695	0.730	0.712
76.10	1.170	1.427	1.313	75.98	0.707	0.711	0.748	0.730
91.07	1.157	1.412	1.296	90.95	0.721	0.727	0.765	0.746
100.78	1.141	1.393	1.278	100.65	0.737	0.746	0.783	0.764
83.37	1.121	1.373	1.256	83.25	0.756	0.766	0.805	0.785
74.73	1.103	1.351	1.236	74.60	0.774	0.788	0.825	0.806
77.89	1.087	1.333	1.216	77.76	0.791	0.806	0.845	0.825
78.93	1.078	1.310	1.195	78.80	0.799	0.829	0.866	0.847
82.75	1.064	1.288	1.175	82.63	0.813	0.851	0.886	0.868
74.31	1.051	1.277	1.161	74.19	0.827	0.862	0.900	0.881
78.20	1.045	1.274	1.160	78.08	0.833	0.865	0.901	0.883
78.30	1.043	1.273	1.158	78.18	0.835	0.866	0.903	0.885
79.22	1.039	1.273	1.157	79.10	0.839	0.866	0.904	0.885
79.99	1.038	1.272	1.154	79.86	0.839	0.867	0.907	0.887
80.69	1.038	1.267	1.154	80.57	0.840	0.872	0.907	0.890
81.25	1.036	1.270	1.155	81.13	0.842	0.869	0.906	0.888
81.92	1.036	1.269	1.156	81.80	0.842	0.870	0.905	0.887
82.61	1.035	1.270	1.156	82.48	0.842	0.869	0.905	0.887
83.23	1.037	1.270	1.156	83.11	0.840	0.869	0.905	0.887
116.60	1.037	1.269	1.156	116.48	0.841	0.870	0.905	0.888
91.17	1.025	1.254	1.135	91.05	0.853	0.885	0.926	0.905
73.98	1.010	1.238	1.121	73.86	0.867	0.901	0.940	0.921
82.63	0.996	1.216	1.107	82.50	0.882	0.923	0.954	0.938
78.39	0.978	1.203	1.091	78.26	0.899	0.936	0.970	0.953
73.67	0.961	1.185	1.075	73.54	0.917	0.954	0.986	0.970
73.77	0.945	1.175	1.061	73.65	0.932	0.964	1.000	0.982
73.21	0.928	1.158	1.042	73.09	0.949	0.981	1.019	1.000
71.94	0.912	1.134	1.023	71.82	0.966	1.005	1.038	1.022
73.54	0.892	1.113	1.002	73.42	0.986	1.026	1.059	1.042
73.67	0.871	1.097	0.977	73.54	1.007	1.042	1.084	1.063
62.00	0.851	1.085	0.962	61.88	1.026	1.054	1.099	1.077
71.94	0.846	0.984	0.960	71.82	1.032	1.155	1.101	1.128

Table A.14 Initial and zeroed readings for steel plate test 1 (continued)

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
72.63	0.845	1.073	0.960	72.50	1.032	1.066	1.101	1.083
73.44	0.847	1.079	0.958	73.32	1.030	1.060	1.103	1.082
73.37	0.843	1.081	0.958	73.25	1.034	1.058	1.103	1.080
73.87	0.840	1.080	0.958	73.75	1.037	1.059	1.103	1.081
74.52	0.842	1.067	0.957	74.40	1.035	1.072	1.104	1.088
74.81	0.841	0.991	0.956	74.69	1.037	1.148	1.105	1.126
75.16	0.841	1.016	0.956	75.04	1.036	1.123	1.105	1.114
67.16	0.835	1.067	0.950	67.04	1.042	1.072	1.112	1.092
76.56	0.825	1.063	0.941	76.43	1.052	1.076	1.120	1.098
73.42	0.817	1.055	0.930	73.29	1.061	1.084	1.131	1.107
75.81	0.807	1.042	0.917	75.69	1.070	1.097	1.144	1.120
76.18	0.791	1.029	0.904	76.06	1.087	1.110	1.157	1.134
77.35	0.777	1.013	0.886	77.22	1.100	1.126	1.175	1.151
75.52	0.754	0.995	0.868	75.39	1.123	1.144	1.193	1.168
75.64	0.733	0.972	0.849	75.52	1.144	1.167	1.212	1.190
74.91	0.713	0.941	0.830	74.79	1.165	1.197	1.232	1.214
74.81	0.692	0.934	0.806	74.69	1.186	1.205	1.255	1.230
73.40	0.668	0.910	0.785	73.27	1.209	1.229	1.276	1.252
59.26	0.647	0.895	0.766	59.14	1.230	1.244	1.295	1.269
73.50	0.644	0.893	0.764	73.38	1.233	1.246	1.297	1.272
75.52	0.642	0.892	0.762	75.39	1.235	1.247	1.299	1.273
77.35	0.641	0.892	0.763	77.22	1.236	1.247	1.298	1.273
78.61	0.641	0.891	0.761	78.49	1.236	1.248	1.300	1.274
79.86	0.640	0.891	0.762	79.74	1.237	1.248	1.299	1.274
81.05	0.639	0.891	0.761	80.92	1.238	1.248	1.300	1.274
82.19	0.640	0.891	0.761	82.07	1.238	1.248	1.300	1.274
83.23	0.639	0.891	0.761	83.11	1.238	1.248	1.300	1.274
84.08	0.639	0.891	0.760	83.96	1.238	1.248	1.301	1.275
84.85	0.639	0.890	0.760	84.73	1.238	1.249	1.301	1.275
118.32	0.635	0.895	0.757	118.20	1.243	1.244	1.304	1.274
73.52	0.614	0.867	0.735	73.40	1.263	1.272	1.326	1.299
80.28	0.593	0.847	0.715	80.16	1.284	1.292	1.346	1.319
66.51	0.570	0.825	0.691	66.39	1.307	1.314	1.370	1.342
79.82	0.547	0.801	0.669	79.70	1.330	1.338	1.392	1.365
85.33	0.524	0.774	0.650	85.21	1.354	1.365	1.412	1.388
84.12	0.500	0.756	0.628	84.00	1.377	1.383	1.433	1.408
87.84	0.480	0.737	0.611	87.72	1.397	1.402	1.450	1.426
87.66	0.462	0.714	0.590	87.54	1.416	1.425	1.471	1.448
84.64	0.444	0.703	0.576	84.52	1.433	1.436	1.485	1.460
82.44	0.439	0.699	0.572	82.32	1.439	1.440	1.489	1.465
82.94	0.437	0.698	0.571	82.82	1.440	1.441	1.490	1.465
84.21	0.437	0.697	0.569	84.08	1.441	1.442	1.492	1.467
85.16	0.436	0.695	0.569	85.04	1.441	1.443	1.492	1.468

Table A.14 Initial and zeroed readings for steel plate test 1 (continued)

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
86.24	0.436	0.696	0.568	86.12	1.442	1.443	1.493	1.468
87.20	0.435	0.696	0.568	87.08	1.442	1.443	1.493	1.468
88.07	0.435	0.695	0.567	87.95	1.442	1.443	1.494	1.469
88.99	0.435	0.696	0.568	88.87	1.443	1.443	1.493	1.468
89.84	0.435	0.695	0.568	89.72	1.443	1.444	1.493	1.468
90.51	0.435	0.695	0.568	90.38	1.443	1.444	1.493	1.468
91.28	0.434	0.696	0.568	91.15	1.443	1.443	1.493	1.468
122.09	0.434	0.694	0.564	121.96	1.443	1.445	1.497	1.471
74.58	0.413	0.671	0.547	74.46	1.464	1.468	1.514	1.491
69.01	0.390	0.649	0.521	68.89	1.487	1.490	1.540	1.515
66.95	0.365	0.627	0.499	66.83	1.512	1.512	1.562	1.537
77.10	0.338	0.602	0.475	76.97	1.539	1.537	1.586	1.561
63.19	0.310	0.578	0.451	63.07	1.567	1.561	1.610	1.586
67.62	0.286	0.556	0.429	67.49	1.592	1.583	1.632	1.608
70.03	0.262	0.536	0.411	69.91	1.615	1.603	1.650	1.627
69.36	0.243	0.516	0.389	69.24	1.635	1.623	1.672	1.648
62.17	0.229	0.505	0.378	62.05	1.648	1.634	1.683	1.659
65.18	0.227	0.504	0.377	65.06	1.650	1.635	1.684	1.660
65.70	0.226	0.503	0.374	65.58	1.651	1.636	1.687	1.661
66.10	0.225	0.501	0.373	65.98	1.652	1.638	1.688	1.663
66.37	0.225	0.500	0.374	66.25	1.653	1.638	1.687	1.663
66.64	0.224	0.500	0.373	66.52	1.653	1.639	1.688	1.663
66.97	0.224	0.500	0.374	66.85	1.653	1.639	1.687	1.663
67.41	0.224	0.500	0.373	67.29	1.654	1.639	1.688	1.663
67.76	0.223	0.500	0.374	67.64	1.654	1.639	1.687	1.663
68.12	0.223	0.500	0.373	67.99	1.654	1.639	1.688	1.664
68.55	0.223	0.500	0.373	68.43	1.654	1.639	1.688	1.664
69.01	0.223	0.500	0.372	68.89	1.654	1.639	1.689	1.664
69.32	0.223	0.500	0.372	69.20	1.654	1.639	1.689	1.664
111.32	0.220	0.498	0.370	111.19	1.657	1.641	1.691	1.666
74.21	0.200	0.479	0.354	74.08	1.677	1.660	1.707	1.684
60.05	0.178	0.458	0.330	59.93	1.699	1.681	1.731	1.706
69.86	0.157	0.437	0.311	69.74	1.720	1.702	1.750	1.726
75.89	0.135	0.418	0.296	75.77	1.742	1.721	1.765	1.743
74.60	0.113	0.399	0.276	74.48	1.764	1.740	1.785	1.763
74.77	0.089	0.377	0.257	74.65	1.788	1.762	1.804	1.783
78.26	0.069	0.355	0.243	78.14	1.809	1.784	1.818	1.801
80.76	0.055	0.336	0.226	80.63	1.822	1.803	1.835	1.819
84.16	0.045	0.317	0.212	84.04	1.833	1.822	1.849	1.836

Table A.15 Initial and zeroed readings for steel plate test 2

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
0.13	1.823	2.060	1.971	0.00	0.000	0.000	0.000	0.000
0.15	1.823	2.060	1.971	0.02	0.000	0.000	0.000	0.000
0.46	1.822	2.060	1.971	0.34	0.000	0.000	0.000	0.000
0.13	1.822	2.060	1.971	0.00	0.000	0.001	0.000	0.001
0.32	1.822	2.059	1.971	0.20	0.000	0.001	0.000	0.001
0.46	1.822	2.059	1.971	0.33	0.000	0.001	0.000	0.000
0.31	1.822	2.059	1.971	0.19	0.000	0.001	0.000	0.000
0.50	1.823	2.060	1.971	0.38	0.000	0.001	0.000	0.000
0.55	1.823	2.060	1.971	0.42	0.000	0.000	0.001	0.001
1.98	1.823	2.060	1.971	1.86	0.000	0.001	0.000	0.001
5.79	1.823	2.059	1.971	5.66	0.000	0.002	0.000	0.001
38.03	1.822	2.060	1.942	37.91	0.001	0.000	0.029	0.015
61.30	1.810	2.061	1.925	61.17	0.013	0.000	0.046	0.023
134.16	1.787	2.058	1.857	134.04	0.035	0.003	0.115	0.059
132.90	1.760	2.026	1.862	132.77	0.063	0.034	0.109	0.072
120.67	1.733	1.994	1.832	120.55	0.089	0.067	0.139	0.103
91.34	1.722	1.984	1.818	91.21	0.101	0.076	0.153	0.115
100.73	1.721	1.986	1.821	100.61	0.102	0.074	0.151	0.112
103.50	1.720	1.987	1.816	103.37	0.103	0.074	0.155	0.114
106.51	1.719	1.983	1.815	106.39	0.104	0.077	0.156	0.116
108.70	1.718	1.982	1.816	108.57	0.104	0.079	0.155	0.117
110.48	1.718	1.982	1.816	110.36	0.105	0.079	0.155	0.117
112.17	1.718	1.981	1.817	112.04	0.105	0.079	0.154	0.117
61.88	1.709	1.971	1.803	61.75	0.114	0.090	0.168	0.129
69.49	1.691	1.955	1.784	69.36	0.132	0.105	0.187	0.146
75.95	1.673	1.931	1.762	75.83	0.150	0.129	0.209	0.169
107.39	1.652	1.908	1.739	107.26	0.171	0.153	0.232	0.192
118.76	1.630	1.886	1.716	118.63	0.192	0.174	0.255	0.215
109.18	1.610	1.865	1.691	109.05	0.213	0.195	0.280	0.237
94.31	1.590	1.842	1.670	94.18	0.233	0.218	0.302	0.260
82.79	1.569	1.819	1.649	82.67	0.254	0.242	0.322	0.282
71.50	1.557	1.806	1.634	71.38	0.266	0.255	0.337	0.296
90.34	1.556	1.806	1.631	90.21	0.267	0.254	0.340	0.297
93.92	1.555	1.801	1.630	93.79	0.268	0.259	0.341	0.300
96.33	1.554	1.801	1.630	96.20	0.269	0.259	0.341	0.300
98.43	1.554	1.802	1.630	98.30	0.269	0.258	0.341	0.300
100.32	1.553	1.802	1.630	100.19	0.269	0.258	0.341	0.299
102.04	1.553	1.802	1.629	101.92	0.270	0.258	0.342	0.300
70.36	1.539	1.787	1.614	70.23	0.284	0.274	0.357	0.315
116.68	1.526	1.771	1.593	116.55	0.297	0.289	0.379	0.334
83.25	1.503	1.748	1.572	83.12	0.320	0.312	0.399	0.356
63.08	1.482	1.720	1.548	62.96	0.341	0.340	0.423	0.382
59.61	1.461	1.700	1.524	59.49	0.361	0.360	0.447	0.404

Table A.15 Initial and zeroed readings for steel plate test 2 (continued)

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
71.52	1.443	1.678	1.502	71.40	0.380	0.382	0.469	0.426
83.52	1.426	1.658	1.482	83.39	0.397	0.402	0.489	0.445
86.56	1.408	1.640	1.463	86.43	0.415	0.421	0.508	0.464
84.48	1.393	1.624	1.446	84.35	0.430	0.436	0.525	0.481
85.41	1.390	1.620	1.439	85.29	0.433	0.441	0.532	0.486
89.05	1.388	1.620	1.439	88.92	0.435	0.441	0.532	0.486
91.07	1.387	1.616	1.438	90.94	0.436	0.445	0.533	0.489
92.88	1.387	1.616	1.438	92.75	0.436	0.445	0.533	0.489
94.19	1.386	1.616	1.438	94.06	0.436	0.445	0.533	0.489
94.91	1.387	1.616	1.438	94.79	0.436	0.444	0.533	0.489
96.16	1.386	1.616	1.438	96.03	0.436	0.445	0.533	0.489
73.98	1.372	1.600	1.423	73.85	0.451	0.460	0.548	0.504
84.39	1.356	1.582	1.404	84.27	0.466	0.478	0.567	0.523
101.30	1.338	1.560	1.382	101.17	0.485	0.500	0.590	0.545
79.78	1.317	1.538	1.358	79.65	0.506	0.523	0.613	0.568
63.79	1.296	1.514	1.335	63.67	0.526	0.546	0.637	0.591
62.61	1.278	1.495	1.314	62.48	0.545	0.565	0.657	0.611
72.11	1.261	1.475	1.294	71.98	0.561	0.586	0.677	0.631
89.18	1.245	1.457	1.277	89.05	0.578	0.604	0.694	0.649
90.59	1.229	1.439	1.259	90.46	0.594	0.621	0.712	0.666
91.38	1.224	1.433	1.252	91.25	0.599	0.627	0.719	0.673
91.57	1.223	1.432	1.252	91.44	0.599	0.629	0.719	0.674
94.29	1.222	1.432	1.252	94.16	0.600	0.628	0.719	0.673
96.14	1.223	1.431	1.252	96.01	0.600	0.630	0.719	0.675
97.47	1.222	1.430	1.250	97.34	0.601	0.631	0.721	0.676
98.49	1.221	1.429	1.249	98.36	0.602	0.632	0.722	0.677
100.94	1.221	1.429	1.249	100.82	0.602	0.632	0.722	0.677
91.65	1.205	1.412	1.232	91.52	0.618	0.648	0.739	0.693
72.17	1.187	1.393	1.211	72.04	0.636	0.668	0.760	0.714
104.35	1.168	1.373	1.189	104.23	0.655	0.687	0.782	0.735
100.11	1.147	1.349	1.165	99.99	0.676	0.711	0.806	0.758
91.23	1.126	1.329	1.144	91.11	0.697	0.732	0.827	0.780
81.59	1.107	1.308	1.121	81.46	0.716	0.753	0.850	0.802
75.35	1.087	1.285	1.100	75.22	0.736	0.776	0.871	0.823
77.62	1.068	1.267	1.081	77.49	0.755	0.793	0.890	0.842
80.65	1.053	1.258	1.069	80.53	0.769	0.802	0.902	0.852
81.59	1.026	1.254	1.067	81.46	0.797	0.806	0.904	0.855
83.29	0.997	1.254	1.066	83.17	0.825	0.806	0.905	0.856
84.75	0.983	1.254	1.065	84.62	0.840	0.806	0.906	0.856
85.77	0.982	1.252	1.065	85.64	0.841	0.809	0.906	0.857
86.89	0.981	1.251	1.065	86.76	0.842	0.809	0.906	0.858
87.87	0.981	1.252	1.065	87.74	0.842	0.808	0.906	0.857
137.53	0.980	1.251	1.065	137.41	0.842	0.810	0.906	0.858

Table A.15 Initial and zeroed readings for steel plate test 2 (continued)

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
75.41	0.960	1.227	1.039	75.29	0.863	0.834	0.932	0.883
100.76	0.939	1.204	1.018	100.63	0.883	0.856	0.953	0.905
77.20	0.917	1.165	0.992	77.07	0.906	0.895	0.980	0.937
70.67	0.894	1.163	0.968	70.55	0.929	0.898	1.003	0.950
74.68	0.872	1.144	0.946	74.56	0.950	0.916	1.025	0.971
80.49	0.852	1.124	0.927	80.36	0.971	0.937	1.045	0.991
84.29	0.832	1.100	0.905	84.16	0.991	0.960	1.066	1.013
68.30	0.815	1.090	0.888	68.18	1.008	0.970	1.083	1.027
79.80	0.812	1.085	0.888	79.67	1.011	0.976	1.083	1.029
80.94	0.810	1.085	0.885	80.82	1.012	0.975	1.086	1.030
81.96	0.809	1.084	0.884	81.84	1.014	0.976	1.087	1.031
82.90	0.809	1.077	0.885	82.77	1.014	0.984	1.086	1.035
83.85	0.808	1.081	0.884	83.73	1.014	0.979	1.087	1.033
84.73	0.808	1.083	0.885	84.60	1.015	0.977	1.086	1.032
86.64	0.807	1.081	0.884	86.51	1.016	0.980	1.087	1.033
104.60	0.791	1.066	0.866	104.48	1.032	0.994	1.105	1.050
59.26	0.767	1.031	0.842	59.13	1.056	1.029	1.129	1.079
84.29	0.745	1.019	0.823	84.16	1.078	1.041	1.148	1.095
92.46	0.721	0.997	0.797	92.33	1.102	1.063	1.174	1.118
91.63	0.697	0.971	0.773	91.50	1.126	1.089	1.198	1.143
89.82	0.673	0.951	0.749	89.69	1.149	1.110	1.222	1.166
83.94	0.650	0.928	0.726	83.81	1.173	1.132	1.245	1.189
83.50	0.628	0.907	0.702	83.37	1.195	1.154	1.269	1.211
83.85	0.621	0.901	0.698	83.73	1.202	1.159	1.273	1.216
86.58	0.620	0.900	0.697	86.45	1.203	1.160	1.274	1.217
88.45	0.618	0.899	0.694	88.32	1.204	1.162	1.277	1.220
89.97	0.618	0.898	0.695	89.84	1.205	1.163	1.276	1.220
91.03	0.617	0.897	0.695	90.90	1.206	1.163	1.276	1.220
92.02	0.617	0.897	0.694	91.90	1.206	1.164	1.277	1.220
128.01	0.613	0.889	0.687	127.89	1.210	1.171	1.284	1.228
60.73	0.589	0.871	0.664	60.61	1.234	1.190	1.307	1.248
95.56	0.568	0.850	0.646	95.43	1.255	1.210	1.325	1.268
93.60	0.542	0.827	0.622	93.48	1.281	1.233	1.349	1.291
86.49	0.516	0.803	0.594	86.37	1.306	1.257	1.377	1.317
80.86	0.491	0.780	0.567	80.73	1.331	1.281	1.405	1.343
84.52	0.469	0.757	0.552	84.39	1.354	1.304	1.419	1.361
85.00	0.448	0.738	0.528	84.87	1.375	1.323	1.443	1.383
81.86	0.428	0.717	0.509	81.73	1.395	1.343	1.462	1.402
83.04	0.417	0.712	0.502	82.92	1.406	1.349	1.469	1.409
82.96	0.415	0.710	0.501	82.83	1.408	1.350	1.470	1.410
84.62	0.414	0.710	0.499	84.50	1.409	1.351	1.472	1.411
85.89	0.413	0.708	0.498	85.76	1.410	1.352	1.473	1.412
87.14	0.412	0.707	0.498	87.01	1.411	1.353	1.473	1.413

Table A.15 Initial and zeroed readings for steel plate test 2 (continued)

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
88.20	0.412	0.707	0.498	88.07	1.411	1.353	1.473	1.413
89.15	0.412	0.707	0.498	89.03	1.411	1.354	1.473	1.414
136.66	0.410	0.698	0.494	136.53	1.413	1.362	1.477	1.419
59.84	0.385	0.680	0.471	59.71	1.438	1.381	1.500	1.440
99.47	0.363	0.660	0.452	99.34	1.460	1.401	1.520	1.460
84.48	0.339	0.639	0.428	84.35	1.484	1.422	1.543	1.482
74.16	0.316	0.618	0.413	74.04	1.507	1.442	1.558	1.500
76.49	0.296	0.601	0.389	76.37	1.527	1.459	1.582	1.521
79.38	0.277	0.582	0.374	79.26	1.546	1.478	1.597	1.538
79.80	0.259	0.567	0.357	79.67	1.564	1.494	1.614	1.554
75.89	0.239	0.551	0.333	75.76	1.583	1.509	1.638	1.574
74.27	0.224	0.535	0.322	74.14	1.599	1.525	1.649	1.587
71.21	0.219	0.531	0.319	71.09	1.604	1.529	1.652	1.590
71.48	0.217	0.531	0.320	71.36	1.606	1.529	1.651	1.590
71.50	0.215	0.528	0.320	71.38	1.607	1.533	1.651	1.592
71.59	0.215	0.528	0.315	71.46	1.608	1.533	1.656	1.594
71.67	0.214	0.528	0.315	71.54	1.609	1.533	1.657	1.595
72.00	0.214	0.527	0.315	71.88	1.609	1.533	1.656	1.595
72.21	0.214	0.527	0.315	72.08	1.609	1.533	1.656	1.595
72.44	0.213	0.528	0.316	72.31	1.609	1.532	1.655	1.594
72.63	0.213	0.527	0.316	72.50	1.610	1.533	1.655	1.594
72.81	0.212	0.526	0.316	72.69	1.610	1.535	1.655	1.595
48.26	0.203	0.516	0.304	48.14	1.620	1.545	1.667	1.606
75.18	0.188	0.500	0.291	75.06	1.635	1.561	1.680	1.620
70.84	0.169	0.480	0.277	70.71	1.654	1.580	1.694	1.637
82.58	0.150	0.461	0.256	82.46	1.673	1.599	1.715	1.657
76.41	0.131	0.445	0.242	76.28	1.692	1.615	1.729	1.672
75.99	0.112	0.426	0.227	75.87	1.711	1.635	1.744	1.689
78.16	0.091	0.410	0.214	78.03	1.732	1.651	1.757	1.704
76.68	0.071	0.391	0.192	76.55	1.752	1.670	1.779	1.724
79.09	0.058	0.375	0.178	78.97	1.764	1.686	1.793	1.739
66.49	0.048	0.365	0.161	66.37	1.774	1.696	1.810	1.753
76.62	0.047	0.359	0.157	76.49	1.776	1.701	1.814	1.758
76.76	0.047	0.359	0.156	76.64	1.776	1.701	1.815	1.758

Table A.16 Initial and zeroed readings for steel plate test 3

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
0.13	1.891	2.126	2.045	0.00	0.000	0.000	0.000	0.000
0.47	1.891	2.126	2.045	0.34	0.000	0.000	0.000	0.000
0.21	1.890	2.126	2.045	0.08	0.000	0.000	0.000	0.000
0.17	1.890	2.126	2.045	0.04	0.001	0.000	0.000	0.000
0.23	1.890	2.126	2.044	0.10	0.000	0.000	0.001	0.000
0.57	1.890	2.125	2.045	0.44	0.001	0.001	0.000	0.000
0.39	1.890	2.126	2.044	0.26	0.001	0.000	0.001	0.000
0.58	1.890	2.126	2.045	0.45	0.001	0.000	0.000	0.000
1.21	1.890	2.126	2.044	1.08	0.001	0.000	0.001	0.000
7.85	1.891	2.126	2.045	7.72	0.000	0.000	0.000	0.000
50.17	1.891	2.116	2.036	50.04	0.000	0.010	0.009	0.009
46.58	1.890	2.115	2.027	46.45	0.000	0.011	0.018	0.015
52.88	1.890	2.126	2.030	52.75	0.001	0.000	0.015	0.007
55.02	1.889	2.129	2.027	54.89	0.002	-0.003	0.017	0.007
56.66	1.889	2.130	2.025	56.53	0.001	-0.004	0.020	0.008
57.01	1.889	2.128	2.026	56.88	0.002	-0.002	0.019	0.008
56.81	1.890	2.128	2.023	56.68	0.001	-0.002	0.022	0.010
57.10	1.890	2.132	2.023	56.97	0.001	-0.006	0.022	0.008
78.09	1.888	2.107	2.011	77.96	0.002	0.019	0.034	0.027
132.63	1.883	2.137	2.000	132.50	0.008	-0.011	0.045	0.017
69.86	1.861	2.112	1.979	69.73	0.029	0.014	0.066	0.040
90.96	1.842	2.087	1.924	90.83	0.049	0.039	0.121	0.080
94.71	1.819	2.071	1.932	94.58	0.072	0.055	0.113	0.084
88.09	1.797	2.050	1.904	87.96	0.094	0.076	0.141	0.108
84.52	1.777	2.028	1.881	84.39	0.114	0.098	0.164	0.131
84.00	1.758	2.004	1.863	83.87	0.133	0.122	0.182	0.152
73.23	1.743	1.988	1.843	73.10	0.148	0.138	0.202	0.170
84.87	1.741	1.990	1.844	84.74	0.150	0.136	0.201	0.168
87.12	1.740	1.990	1.844	86.99	0.150	0.136	0.201	0.169
89.20	1.739	1.983	1.840	89.07	0.152	0.143	0.205	0.174
90.92	1.739	1.985	1.840	90.79	0.152	0.141	0.205	0.173
92.73	1.739	1.984	1.840	92.60	0.152	0.142	0.205	0.173
94.50	1.739	1.985	1.840	94.37	0.152	0.141	0.205	0.173
95.99	1.739	1.986	1.839	95.86	0.152	0.140	0.206	0.173
125.27	1.739	1.986	1.840	125.14	0.152	0.140	0.205	0.173
95.25	1.723	1.966	1.811	95.12	0.168	0.160	0.234	0.197
75.74	1.703	1.943	1.794	75.62	0.188	0.183	0.251	0.217
55.00	1.684	1.924	1.768	54.87	0.207	0.202	0.277	0.239
84.71	1.664	1.903	1.751	84.58	0.227	0.223	0.293	0.258
88.55	1.645	1.879	1.727	88.42	0.246	0.247	0.318	0.283
86.97	1.625	1.861	1.704	86.84	0.266	0.265	0.341	0.303
84.12	1.606	1.839	1.684	83.99	0.285	0.287	0.361	0.324
79.78	1.587	1.816	1.661	79.65	0.304	0.310	0.384	0.347

Table A.16 Initial and zeroed readings for steel plate test 3 (continued)

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
83.98	1.580	1.808	1.654	83.85	0.311	0.318	0.391	0.355
86.18	1.577	1.799	1.650	86.05	0.313	0.327	0.395	0.361
88.74	1.577	1.798	1.649	88.61	0.314	0.328	0.396	0.362
90.90	1.576	1.806	1.649	90.77	0.315	0.320	0.396	0.358
92.90	1.575	1.806	1.650	92.77	0.315	0.320	0.395	0.358
94.50	1.576	1.807	1.649	94.37	0.315	0.319	0.395	0.357
96.04	1.575	1.806	1.649	95.91	0.316	0.320	0.396	0.358
135.56	1.574	1.737	1.641	135.43	0.317	0.389	0.404	0.397
68.72	1.554	1.782	1.621	68.59	0.337	0.344	0.424	0.384
112.42	1.537	1.764	1.603	112.29	0.354	0.362	0.442	0.402
65.72	1.515	1.739	1.580	65.59	0.376	0.387	0.465	0.426
57.41	1.494	1.713	1.556	57.28	0.397	0.413	0.489	0.451
64.00	1.475	1.691	1.533	63.87	0.416	0.435	0.512	0.473
73.23	1.456	1.674	1.511	73.10	0.435	0.452	0.534	0.493
75.64	1.437	1.651	1.491	75.51	0.454	0.475	0.554	0.515
71.52	1.418	1.627	1.466	71.39	0.473	0.499	0.579	0.539
71.21	1.412	1.623	1.462	71.08	0.479	0.503	0.583	0.543
74.16	1.410	1.619	1.458	74.04	0.481	0.507	0.586	0.546
75.66	1.409	1.620	1.458	75.53	0.482	0.506	0.586	0.546
77.24	1.408	1.619	1.458	77.11	0.483	0.507	0.587	0.547
78.86	1.408	1.616	1.458	78.73	0.483	0.510	0.587	0.549
80.09	1.408	1.616	1.457	79.96	0.483	0.510	0.588	0.549
81.00	1.408	1.616	1.455	80.88	0.483	0.510	0.590	0.550
130.32	1.406	1.616	1.454	130.19	0.485	0.510	0.591	0.550
58.36	1.384	1.591	1.427	58.23	0.507	0.535	0.618	0.576
93.13	1.366	1.569	1.407	93.00	0.524	0.557	0.638	0.597
78.43	1.345	1.546	1.384	78.30	0.546	0.580	0.661	0.620
72.44	1.326	1.526	1.361	72.31	0.565	0.600	0.684	0.642
72.07	1.306	1.502	1.339	71.94	0.584	0.624	0.706	0.665
74.27	1.288	1.483	1.318	74.14	0.603	0.643	0.727	0.685
82.46	1.269	1.463	1.296	82.33	0.622	0.663	0.749	0.706
83.69	1.257	1.450	1.283	83.56	0.634	0.676	0.762	0.719
85.62	1.255	1.446	1.282	85.49	0.635	0.679	0.763	0.721
87.41	1.255	1.447	1.280	87.28	0.636	0.679	0.765	0.722
88.99	1.253	1.445	1.280	88.86	0.638	0.681	0.765	0.723
90.53	1.253	1.444	1.279	90.40	0.638	0.682	0.766	0.724
91.67	1.253	1.444	1.279	91.54	0.638	0.682	0.766	0.724
92.79	1.252	1.445	1.279	92.66	0.639	0.681	0.766	0.723
93.89	1.252	1.444	1.279	93.76	0.639	0.682	0.766	0.724
128.59	1.252	1.444	1.279	128.46	0.639	0.682	0.766	0.724
100.55	1.233	1.424	1.256	100.42	0.658	0.702	0.789	0.746
69.97	1.215	1.404	1.236	69.84	0.676	0.722	0.809	0.765
77.45	1.200	1.389	1.218	77.32	0.691	0.737	0.827	0.782

Table A.16 Initial and zeroed readings for steel plate test 3 (continued)

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
97.41	1.185	1.374	1.201	97.28	0.706	0.752	0.844	0.798
87.95	1.168	1.354	1.183	87.82	0.723	0.772	0.862	0.817
79.88	1.152	1.338	1.163	79.75	0.739	0.788	0.881	0.835
79.34	1.135	1.321	1.144	79.21	0.756	0.805	0.901	0.853
80.73	1.116	1.299	1.120	80.60	0.775	0.827	0.925	0.876
77.37	1.095	1.277	1.102	77.24	0.796	0.849	0.943	0.896
74.04	1.089	1.269	1.095	73.91	0.802	0.857	0.950	0.903
75.31	1.087	1.270	1.093	75.18	0.804	0.856	0.952	0.904
76.10	1.086	1.267	1.092	75.97	0.805	0.859	0.953	0.906
76.89	1.085	1.265	1.091	76.76	0.806	0.860	0.954	0.907
78.01	1.084	1.266	1.090	77.88	0.806	0.860	0.955	0.907
78.95	1.084	1.266	1.090	78.82	0.807	0.860	0.955	0.907
79.90	1.084	1.266	1.090	79.77	0.807	0.860	0.955	0.907
123.79	1.083	1.262	1.088	123.66	0.807	0.864	0.957	0.910
60.38	1.060	1.238	1.065	60.25	0.831	0.888	0.980	0.934
94.39	1.041	1.221	1.044	94.26	0.849	0.905	1.001	0.953
80.03	1.022	1.201	1.020	79.90	0.869	0.925	1.025	0.975
72.38	1.003	1.191	1.004	72.25	0.888	0.935	1.041	0.988
78.70	0.984	1.168	0.983	78.57	0.907	0.958	1.062	1.010
82.90	0.965	1.148	0.964	82.77	0.925	0.978	1.081	1.030
83.37	0.945	1.121	0.942	83.25	0.946	1.005	1.102	1.053
79.49	0.923	1.107	0.920	79.36	0.968	1.019	1.125	1.072
72.98	0.904	1.089	0.900	72.85	0.987	1.037	1.144	1.091
75.83	0.900	1.084	0.896	75.70	0.991	1.042	1.149	1.095
77.35	0.899	1.085	0.897	77.22	0.992	1.041	1.148	1.095
78.63	0.898	1.056	0.896	78.51	0.993	1.070	1.149	1.110
79.57	0.897	1.011	0.894	79.44	0.994	1.115	1.151	1.133
80.44	0.896	1.072	0.894	80.31	0.995	1.054	1.151	1.102
81.36	0.895	1.072	0.893	81.23	0.995	1.054	1.152	1.103
82.34	0.896	1.072	0.892	82.21	0.995	1.054	1.153	1.103
127.99	0.895	1.081	0.893	127.86	0.996	1.045	1.152	1.098
65.60	0.872	1.036	0.870	65.47	1.019	1.090	1.175	1.132
93.50	0.853	1.037	0.852	93.37	1.038	1.089	1.193	1.141
68.93	0.831	1.017	0.831	68.80	1.060	1.109	1.214	1.162
73.50	0.811	1.002	0.813	73.37	1.080	1.124	1.232	1.178
86.04	0.793	0.984	0.793	85.91	1.098	1.142	1.252	1.197
83.75	0.775	0.966	0.775	83.62	1.116	1.160	1.270	1.215
78.39	0.755	0.946	0.755	78.26	1.136	1.180	1.289	1.235
77.12	0.735	0.925	0.736	76.99	1.156	1.201	1.309	1.255
79.45	0.715	0.908	0.714	79.32	1.176	1.218	1.331	1.274
81.07	0.703	0.894	0.703	80.94	1.188	1.232	1.342	1.287
83.13	0.701	0.895	0.702	83.00	1.190	1.231	1.343	1.287
85.35	0.700	0.893	0.701	85.22	1.191	1.233	1.344	1.289

Table A.16 Initial and zeroed readings for steel plate test 3 (continued)

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
86.70	0.699	0.892	0.699	86.57	1.192	1.234	1.346	1.290
88.22	0.698	0.893	0.699	88.09	1.193	1.233	1.346	1.290
89.45	0.698	0.892	0.699	89.32	1.193	1.234	1.346	1.290
90.65	0.697	0.892	0.699	90.52	1.193	1.234	1.346	1.290
122.06	0.697	0.892	0.699	121.94	1.193	1.234	1.346	1.290
83.31	0.674	0.870	0.675	83.18	1.217	1.255	1.370	1.313
96.26	0.653	0.849	0.654	96.13	1.238	1.277	1.390	1.333
66.91	0.632	0.829	0.634	66.78	1.259	1.297	1.411	1.354
80.55	0.612	0.814	0.615	80.42	1.279	1.312	1.430	1.371
87.18	0.592	0.794	0.594	87.05	1.298	1.332	1.450	1.391
83.23	0.571	0.773	0.576	83.10	1.319	1.353	1.469	1.411
85.89	0.549	0.754	0.554	85.76	1.342	1.372	1.491	1.432
87.89	0.524	0.729	0.529	87.76	1.367	1.397	1.516	1.457
63.89	0.501	0.707	0.507	63.77	1.390	1.419	1.538	1.478
89.99	0.499	0.705	0.506	89.86	1.392	1.421	1.539	1.480
92.61	0.497	0.703	0.506	92.48	1.394	1.423	1.539	1.481
94.52	0.496	0.702	0.502	94.39	1.395	1.424	1.543	1.483
96.10	0.495	0.703	0.502	95.97	1.395	1.423	1.543	1.483
97.51	0.495	0.703	0.502	97.38	1.396	1.423	1.543	1.483
99.03	0.495	0.703	0.501	98.90	1.396	1.423	1.544	1.484
100.26	0.494	0.703	0.502	100.13	1.397	1.423	1.543	1.483
106.83	0.474	0.682	0.482	106.70	1.417	1.443	1.563	1.503
76.29	0.450	0.660	0.460	76.16	1.441	1.466	1.585	1.526
80.73	0.430	0.643	0.443	80.60	1.461	1.483	1.602	1.542
92.02	0.410	0.625	0.424	91.89	1.481	1.501	1.621	1.561
80.40	0.390	0.607	0.405	80.27	1.501	1.519	1.640	1.579
74.48	0.370	0.590	0.389	74.35	1.521	1.536	1.656	1.596
78.53	0.350	0.575	0.369	78.40	1.541	1.551	1.676	1.614
79.11	0.330	0.556	0.355	78.98	1.561	1.570	1.690	1.630
76.29	0.308	0.535	0.332	76.16	1.583	1.591	1.713	1.652
66.76	0.288	0.516	0.311	66.63	1.603	1.610	1.733	1.672
70.44	0.284	0.512	0.310	70.31	1.607	1.614	1.735	1.674
71.57	0.282	0.512	0.306	71.44	1.609	1.614	1.738	1.676
72.02	0.280	0.512	0.309	71.89	1.610	1.614	1.736	1.675
72.54	0.280	0.509	0.296	72.41	1.611	1.617	1.749	1.683
73.10	0.279	0.509	0.306	72.97	1.611	1.617	1.738	1.678
73.67	0.279	0.508	0.307	73.54	1.612	1.618	1.738	1.678
74.08	0.278	0.508	0.304	73.95	1.612	1.618	1.741	1.680
112.98	0.277	0.506	0.304	112.85	1.614	1.620	1.741	1.681
61.05	0.255	0.485	0.288	60.92	1.636	1.641	1.756	1.699
83.81	0.235	0.466	0.265	83.68	1.656	1.660	1.780	1.720
71.23	0.212	0.445	0.245	71.10	1.679	1.681	1.799	1.740
71.07	0.190	0.424	0.233	70.94	1.700	1.702	1.812	1.757

Table A.16 Initial and zeroed readings for steel plate test 3 (continued)

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
71.21	0.170	0.406	0.213	71.08	1.721	1.720	1.832	1.776
68.82	0.148	0.386	0.195	68.69	1.743	1.740	1.850	1.795
71.32	0.125	0.367	0.174	71.19	1.765	1.759	1.871	1.815
79.88	0.101	0.348	0.152	79.75	1.790	1.778	1.893	1.836
87.97	0.076	0.328	0.128	87.84	1.815	1.798	1.917	1.858
85.60	0.066	0.320	0.120	85.47	1.825	1.806	1.925	1.865
85.10	0.063	0.320	0.116	84.97	1.828	1.806	1.929	1.867
85.52	0.062	0.317	0.116	85.39	1.828	1.809	1.929	1.869
86.02	0.061	0.316	0.115	85.89	1.830	1.810	1.930	1.870
86.43	0.060	0.316	0.113	86.30	1.830	1.810	1.932	1.871

Table A.17 Initial and zeroed readings for steel plate & oil test 1

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
0.58	1.192	1.973	1.984	0.00	0.000	0.000	0.000	0.000
0.72	1.194	1.972	1.983	0.14	0.002	0.001	0.001	0.001
0.70	1.195	1.972	1.984	0.12	0.003	0.001	0.000	0.001
0.70	1.196	1.972	1.984	0.12	0.004	0.000	0.000	0.000
0.74	1.195	1.972	1.984	0.17	0.003	0.001	0.000	0.000
0.74	1.196	1.972	1.984	0.17	0.004	0.001	0.000	0.001
0.79	1.196	1.973	1.984	0.21	0.004	0.000	0.001	0.000
0.68	1.197	1.972	1.984	0.10	0.005	0.001	0.000	0.001
0.70	1.197	1.972	1.984	0.12	0.005	0.001	0.000	0.000
0.70	1.196	1.972	1.984	0.12	0.004	0.001	0.001	0.001
1.28	1.195	1.972	1.983	0.70	0.003	0.001	0.001	0.001
12.21	1.195	1.972	1.983	11.63	0.003	0.001	0.001	0.001
26.71	1.195	1.971	1.984	26.13	0.003	0.001	0.001	0.001
51.92	1.192	1.972	1.983	51.34	0.000	0.000	0.001	0.001
78.42	1.192	1.971	1.984	77.85	0.000	0.002	0.000	0.001
118.51	1.194	1.967	1.983	117.93	0.002	0.005	0.001	0.003
106.32	1.220	1.965	1.973	105.74	0.028	0.007	0.012	0.009
106.38	1.239	1.960	1.968	105.80	0.047	0.012	0.017	0.014
98.60	1.260	1.952	1.960	98.02	0.068	0.021	0.024	0.023
91.17	1.277	1.948	1.956	90.59	0.085	0.024	0.028	0.026
86.54	1.292	1.944	1.948	85.96	0.100	0.028	0.036	0.032
91.29	1.309	1.936	1.944	90.72	0.117	0.036	0.040	0.038
100.19	1.322	1.934	1.940	99.61	0.130	0.039	0.044	0.041
98.93	1.343	1.926	1.933	98.35	0.151	0.047	0.051	0.049
88.69	1.365	1.917	1.928	88.11	0.173	0.056	0.057	0.056
94.50	1.388	1.915	1.918	93.92	0.196	0.058	0.066	0.062
94.01	1.413	1.899	1.908	93.43	0.221	0.074	0.077	0.075
91.07	1.448	1.886	1.898	90.49	0.256	0.086	0.087	0.087
87.76	1.473	1.884	1.893	87.18	0.281	0.089	0.091	0.090
101.97	1.475	1.883	1.893	101.39	0.283	0.089	0.091	0.090
105.16	1.477	1.883	1.892	104.58	0.285	0.089	0.093	0.091
108.22	1.474	1.885	1.891	107.64	0.282	0.088	0.093	0.091
110.87	1.473	1.885	1.890	110.29	0.281	0.088	0.094	0.091
113.04	1.475	1.885	1.889	112.46	0.283	0.088	0.095	0.091
114.84	1.477	1.885	1.890	114.26	0.285	0.088	0.094	0.091
116.37	1.471	1.884	1.889	115.80	0.279	0.088	0.095	0.092
58.41	1.500	1.873	1.882	57.84	0.308	0.100	0.102	0.101
94.19	1.510	1.871	1.878	93.61	0.318	0.101	0.106	0.104
88.29	1.538	1.862	1.865	87.72	0.346	0.111	0.119	0.115
106.59	1.562	1.855	1.858	106.01	0.370	0.118	0.126	0.122
84.51	1.595	1.843	1.848	83.93	0.403	0.129	0.136	0.132
100.98	1.622	1.831	1.840	100.40	0.430	0.141	0.144	0.143
90.09	1.651	1.819	1.829	89.52	0.459	0.154	0.155	0.154

Table A.17 Initial and zeroed readings for steel plate & oil test 1 (continued)

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
95.29	1.674	1.811	1.818	94.71	0.482	0.161	0.166	0.163
89.06	1.706	1.801	1.807	88.48	0.514	0.171	0.177	0.174
91.19	1.730	1.790	1.798	90.61	0.538	0.182	0.187	0.184
87.28	1.760	1.779	1.779	86.70	0.568	0.194	0.205	0.200
86.27	1.792	1.765	1.771	85.69	0.600	0.207	0.213	0.210
88.15	1.821	1.755	1.758	87.57	0.629	0.217	0.226	0.222
89.85	1.856	1.740	1.742	89.27	0.664	0.232	0.242	0.237
89.43	1.889	1.723	1.729	88.85	0.697	0.249	0.255	0.252
92.85	1.905	1.714	1.720	92.27	0.713	0.259	0.265	0.262
99.01	1.909	1.716	1.722	98.43	0.717	0.256	0.262	0.259
103.63	1.909	1.715	1.722	103.05	0.717	0.258	0.263	0.260
107.25	1.908	1.715	1.722	106.67	0.716	0.258	0.262	0.260
110.23	1.910	1.716	1.722	109.65	0.718	0.257	0.262	0.260
112.82	1.910	1.717	1.722	112.24	0.718	0.256	0.262	0.259
114.88	1.906	1.717	1.722	114.31	0.714	0.255	0.263	0.259
100.94	1.913	1.712	1.716	100.36	0.721	0.260	0.269	0.264
82.79	1.938	1.688	1.690	82.21	0.746	0.284	0.294	0.289
94.75	1.960	1.692	1.698	94.17	0.768	0.280	0.287	0.283
96.94	1.978	1.688	1.686	96.36	0.786	0.284	0.298	0.291
95.50	2.002	1.671	1.664	94.92	0.810	0.302	0.320	0.311
100.65	2.017	1.662	1.664	100.07	0.825	0.310	0.320	0.315
92.23	2.039	1.653	1.655	91.65	0.847	0.320	0.329	0.324
95.18	2.054	1.639	1.648	94.61	0.862	0.334	0.336	0.335
84.80	2.074	1.632	1.632	84.22	0.882	0.340	0.352	0.346
90.86	2.092	1.626	1.628	90.28	0.900	0.347	0.357	0.352
90.98	2.110	1.614	1.617	90.41	0.918	0.359	0.368	0.363
93.24	2.126	1.599	1.603	92.66	0.934	0.374	0.382	0.378
92.14	2.147	1.592	1.594	91.56	0.955	0.380	0.391	0.386
90.78	2.167	1.573	1.578	90.20	0.975	0.399	0.406	0.403
95.60	2.180	1.567	1.570	95.02	0.988	0.405	0.414	0.409
102.28	2.182	1.567	1.567	101.70	0.990	0.405	0.417	0.411
106.88	2.184	1.564	1.567	106.30	0.992	0.408	0.417	0.412
110.33	2.186	1.564	1.568	109.75	0.994	0.409	0.417	0.413
113.19	2.184	1.564	1.567	112.61	0.992	0.408	0.417	0.413
115.55	2.182	1.564	1.567	114.97	0.990	0.409	0.417	0.413
117.57	2.183	1.563	1.567	117.00	0.991	0.409	0.417	0.413
56.95	2.198	1.550	1.551	56.37	1.006	0.422	0.433	0.428
100.57	2.210	1.541	1.544	99.99	1.018	0.432	0.440	0.436
81.01	2.227	1.526	1.528	80.43	1.035	0.447	0.456	0.451
104.64	2.244	1.515	1.514	104.06	1.052	0.458	0.471	0.464
76.64	2.260	1.500	1.502	76.07	1.068	0.473	0.482	0.477
104.85	2.265	1.490	1.490	104.27	1.073	0.482	0.494	0.488
81.84	2.278	1.477	1.479	81.26	1.086	0.496	0.505	0.501

Table A.17 Initial and zeroed readings for steel plate & oil test 1 (continued)

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
102.32	2.284	1.465	1.467	101.75	1.092	0.507	0.517	0.512
89.18	2.300	1.454	1.457	88.61	1.108	0.519	0.527	0.523
94.56	2.306	1.442	1.445	93.99	1.114	0.530	0.539	0.535
96.47	2.317	1.429	1.433	95.89	1.125	0.544	0.551	0.547
88.50	2.326	1.413	1.421	87.92	1.134	0.560	0.563	0.561
97.27	2.331	1.411	1.415	96.70	1.139	0.561	0.569	0.565
102.55	2.330	1.412	1.414	101.97	1.138	0.560	0.571	0.565
105.80	2.332	1.411	1.412	105.22	1.140	0.561	0.572	0.567
108.45	2.328	1.411	1.410	107.87	1.136	0.561	0.574	0.568
110.68	2.328	1.411	1.409	110.10	1.136	0.562	0.575	0.569
112.65	2.326	1.411	1.409	112.07	1.134	0.562	0.575	0.569
119.16	2.324	1.411	1.409	118.58	1.132	0.562	0.576	0.569
115.22	2.331	1.399	1.398	114.64	1.139	0.573	0.587	0.580
87.30	2.343	1.386	1.382	86.72	1.151	0.587	0.603	0.595
116.00	2.349	1.373	1.369	115.42	1.157	0.600	0.615	0.607
92.85	2.356	1.360	1.355	92.27	1.164	0.613	0.629	0.621
103.88	2.365	1.348	1.344	103.30	1.173	0.624	0.640	0.632
89.85	2.372	1.332	1.331	89.27	1.180	0.640	0.653	0.647
92.31	2.379	1.321	1.318	91.73	1.187	0.651	0.666	0.659
91.87	2.385	1.302	1.304	91.30	1.193	0.670	0.680	0.675
89.64	2.400	1.295	1.290	89.06	1.208	0.677	0.694	0.686
89.58	2.404	1.263	1.276	89.00	1.212	0.709	0.708	0.709
89.74	2.414	1.252	1.262	89.16	1.222	0.721	0.722	0.722
90.88	2.420	1.256	1.254	90.30	1.228	0.716	0.730	0.723
98.14	2.420	1.248	1.254	97.57	1.228	0.725	0.730	0.728
101.79	2.424	1.224	1.252	101.21	1.232	0.749	0.732	0.741
104.85	2.423	1.221	1.251	104.27	1.231	0.752	0.733	0.742
107.48	2.424	1.215	1.251	106.90	1.232	0.757	0.733	0.745
109.69	2.427	1.238	1.250	109.11	1.235	0.735	0.734	0.735
112.65	2.428	1.231	1.251	112.07	1.236	0.741	0.734	0.737
76.69	2.436	1.228	1.239	76.11	1.244	0.744	0.745	0.745
108.32	2.445	1.215	1.222	107.75	1.253	0.757	0.762	0.760
75.53	2.458	1.205	1.202	74.95	1.266	0.768	0.782	0.775
73.46	2.463	1.164	1.185	72.88	1.271	0.809	0.799	0.804
92.56	2.470	1.148	1.171	91.98	1.278	0.825	0.813	0.819
71.00	2.476	1.078	1.154	70.42	1.284	0.895	0.830	0.862
83.62	2.482	1.119	1.139	83.04	1.290	0.854	0.845	0.849
80.20	2.485	1.125	1.128	79.62	1.293	0.847	0.856	0.852
78.67	2.492	1.117	1.107	78.09	1.300	0.856	0.877	0.866
87.20	2.498	1.091	1.096	86.62	1.306	0.882	0.888	0.885
84.47	2.501	1.097	1.086	83.89	1.309	0.876	0.898	0.887
90.32	2.502	1.091	1.086	89.74	1.310	0.881	0.898	0.890
93.78	2.507	1.091	1.084	93.20	1.315	0.881	0.900	0.891

Table A.17 Initial and zeroed readings for steel plate & oil test 1 (continued)

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
96.55	2.504	1.091	1.084	95.97	1.312	0.881	0.901	0.891
99.05	2.506	1.092	1.084	98.48	1.314	0.880	0.900	0.890
103.90	2.505	1.092	1.084	103.32	1.313	0.880	0.900	0.890
90.78	2.514	1.079	1.072	90.20	1.322	0.893	0.912	0.903
93.61	2.515	1.027	1.060	93.03	1.323	0.945	0.924	0.935
96.57	2.518	1.032	1.043	95.99	1.326	0.940	0.942	0.941
82.07	2.523	1.010	1.025	81.49	1.331	0.962	0.959	0.960
108.95	2.524	1.025	1.016	108.37	1.332	0.948	0.968	0.958
77.89	2.531	1.009	1.003	77.31	1.339	0.964	0.982	0.973
102.18	2.533	0.987	0.989	101.60	1.341	0.985	0.995	0.990
87.82	2.540	0.979	0.970	87.24	1.348	0.994	1.014	1.004
80.08	2.541	0.968	0.953	79.50	1.349	1.005	1.031	1.018
91.67	2.546	0.895	0.938	91.09	1.354	1.078	1.046	1.062
62.59	2.552	0.933	0.920	62.02	1.360	1.040	1.064	1.052
82.85	2.553	0.923	0.917	82.27	1.361	1.049	1.068	1.058
85.50	2.556	0.926	0.917	84.92	1.364	1.047	1.067	1.057
87.69	2.558	0.929	0.916	87.12	1.366	1.044	1.068	1.056
89.91	2.557	0.927	0.916	89.33	1.365	1.046	1.068	1.057
91.87	2.558	0.926	0.915	91.30	1.366	1.047	1.070	1.058
55.31	2.558	0.915	0.902	54.73	1.366	1.057	1.082	1.070
106.57	2.562	0.890	0.891	105.99	1.370	1.083	1.093	1.088
62.66	2.566	0.882	0.868	62.08	1.374	1.091	1.116	1.103
88.87	2.565	0.870	0.856	88.29	1.373	1.103	1.129	1.116
85.75	2.569	0.855	0.842	85.17	1.377	1.118	1.143	1.130
79.40	2.570	0.823	0.831	78.82	1.378	1.149	1.153	1.151
95.33	2.575	0.835	0.821	94.75	1.383	1.137	1.163	1.150
77.84	2.576	0.822	0.806	77.27	1.384	1.151	1.178	1.164
95.25	2.578	0.803	0.794	94.67	1.386	1.170	1.190	1.180
81.16	2.576	0.773	0.780	80.58	1.384	1.199	1.205	1.202
88.96	2.579	0.782	0.763	88.38	1.387	1.190	1.221	1.206
95.10	2.584	0.776	0.760	94.52	1.392	1.196	1.224	1.210
99.36	2.585	0.778	0.760	98.79	1.393	1.194	1.224	1.209
102.72	2.588	0.777	0.759	102.14	1.396	1.195	1.225	1.210
105.28	2.587	0.777	0.760	104.70	1.395	1.195	1.224	1.210
108.43	2.585	0.775	0.759	107.85	1.393	1.197	1.225	1.211
76.83	2.592	0.766	0.751	76.25	1.400	1.206	1.234	1.220
79.42	2.587	0.754	0.739	78.84	1.395	1.218	1.245	1.232
92.93	2.592	0.745	0.725	92.35	1.400	1.227	1.259	1.243
80.76	2.589	0.732	0.712	80.18	1.397	1.241	1.272	1.256
93.43	2.591	0.719	0.701	92.85	1.399	1.253	1.283	1.268
82.27	2.588	0.707	0.673	81.69	1.396	1.266	1.311	1.288
93.34	2.591	0.692	0.678	92.76	1.399	1.280	1.306	1.293
81.09	2.591	0.683	0.665	80.51	1.399	1.290	1.320	1.305

Table A.17 Initial and zeroed readings for steel plate & oil test 1 (continued)

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
89.29	2.592	0.671	0.654	88.71	1.400	1.301	1.331	1.316
83.12	2.592	0.654	0.638	82.54	1.400	1.319	1.346	1.333
79.00	2.591	0.633	0.618	78.42	1.399	1.340	1.366	1.353
89.74	2.594	0.619	0.600	89.16	1.402	1.354	1.384	1.369
95.60	2.592	0.616	0.596	95.02	1.400	1.357	1.388	1.373
100.07	2.592	0.614	0.595	99.49	1.400	1.359	1.389	1.374
103.65	2.596	0.610	0.594	103.07	1.404	1.362	1.390	1.376
106.44	2.597	0.611	0.595	105.86	1.405	1.362	1.390	1.376
109.75	2.596	0.611	0.592	109.17	1.404	1.362	1.393	1.377
58.10	2.596	0.595	0.576	57.53	1.404	1.378	1.408	1.393
105.43	2.597	0.583	0.565	104.85	1.405	1.389	1.419	1.404

Table A.18 Initial and zeroed readings for steel plate & oil test 2

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
0.62	1.481	2.006	2.065	0.00	0.000	0.000	0.000	0.000
0.68	1.489	2.005	2.065	0.06	0.008	0.000	0.000	0.000
0.68	1.484	2.006	2.065	0.06	0.003	0.000	0.000	0.000
0.70	1.484	2.005	2.065	0.08	0.003	0.000	0.000	0.000
0.72	1.489	2.006	2.065	0.10	0.008	0.000	0.000	0.000
0.70	1.481	2.006	2.065	0.08	0.000	0.001	0.000	0.000
0.64	1.480	2.005	2.064	0.02	-0.001	0.000	0.001	0.000
0.66	1.486	2.006	2.064	0.04	0.005	0.000	0.001	0.000
2.92	1.484	2.006	2.064	2.30	0.003	0.000	0.001	0.001
12.89	1.489	2.005	2.065	12.27	0.008	0.001	0.000	0.000
29.07	1.484	2.005	2.064	28.45	0.003	0.000	0.001	0.001
47.30	1.481	2.005	2.064	46.68	0.000	0.000	0.001	0.001
83.51	1.486	2.005	2.059	82.89	0.005	0.000	0.005	0.003
123.32	1.489	2.005	2.057	122.70	0.008	0.001	0.008	0.004
115.86	1.508	1.999	2.048	115.24	0.027	0.007	0.017	0.012
105.95	1.537	1.992	2.041	105.32	0.056	0.013	0.024	0.018
101.97	1.553	1.987	2.036	101.35	0.072	0.019	0.028	0.024
104.52	1.567	1.979	2.029	103.90	0.086	0.027	0.036	0.031
102.34	1.588	1.971	2.022	101.72	0.107	0.035	0.043	0.039
95.91	1.610	1.964	1.974	95.29	0.129	0.042	0.091	0.066
100.73	1.634	1.955	2.003	100.11	0.153	0.051	0.062	0.057
93.53	1.666	1.940	1.991	92.91	0.185	0.065	0.074	0.070
92.47	1.685	1.927	1.977	91.85	0.204	0.079	0.088	0.083
98.79	1.690	1.930	1.976	98.17	0.209	0.076	0.089	0.083
102.26	1.693	1.931	1.976	101.64	0.212	0.075	0.089	0.082
105.06	1.690	1.931	1.976	104.44	0.209	0.075	0.088	0.082
107.62	1.690	1.931	1.976	107.00	0.209	0.075	0.089	0.082
112.28	1.690	1.930	1.976	111.66	0.209	0.075	0.089	0.082
99.94	1.720	1.914	1.960	99.32	0.239	0.091	0.105	0.098
75.44	1.749	1.895	1.940	74.82	0.268	0.111	0.125	0.118
110.77	1.784	1.885	1.928	110.15	0.303	0.121	0.137	0.129
71.80	1.803	1.869	1.906	71.18	0.322	0.137	0.159	0.148
107.58	1.824	1.859	1.902	106.96	0.343	0.147	0.163	0.155
85.46	1.838	1.846	1.879	84.84	0.357	0.160	0.186	0.173
104.72	1.851	1.838	1.881	104.10	0.370	0.168	0.183	0.176
86.74	1.870	1.828	1.868	86.12	0.389	0.178	0.197	0.188
109.36	1.892	1.807	1.853	108.74	0.411	0.199	0.212	0.205
92.91	1.913	1.797	1.836	92.29	0.432	0.208	0.228	0.218
88.40	1.934	1.777	1.817	87.78	0.453	0.228	0.248	0.238
101.31	1.948	1.770	1.809	100.69	0.467	0.236	0.256	0.246
113.21	1.956	1.771	1.809	112.59	0.475	0.235	0.256	0.246
117.91	1.951	1.769	1.810	117.29	0.470	0.236	0.255	0.246
121.20	1.961	1.764	1.810	120.58	0.480	0.242	0.255	0.249

Table A.18 Initial and zeroed readings for steel plate & oil test 2 (continued)

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
125.07	1.959	1.766	1.807	124.44	0.478	0.240	0.258	0.249
56.18	1.975	1.749	1.790	55.56	0.494	0.256	0.275	0.266
106.44	1.988	1.743	1.777	105.82	0.507	0.262	0.288	0.275
79.69	2.007	1.724	1.764	79.07	0.526	0.282	0.301	0.292
117.41	2.026	1.713	1.753	116.79	0.545	0.292	0.312	0.302
83.89	2.039	1.679	1.737	83.27	0.558	0.327	0.328	0.327
114.08	2.058	1.687	1.726	113.46	0.577	0.319	0.339	0.329
97.11	2.066	1.675	1.706	96.49	0.585	0.330	0.359	0.345
93.96	2.087	1.652	1.699	93.34	0.606	0.354	0.366	0.360
100.98	2.101	1.648	1.680	100.36	0.620	0.358	0.385	0.371
80.56	2.120	1.629	1.650	79.94	0.639	0.377	0.415	0.396
87.38	2.136	1.614	1.648	86.76	0.655	0.392	0.417	0.404
93.98	2.149	1.611	1.640	93.36	0.668	0.395	0.425	0.410
97.61	2.147	1.611	1.643	96.99	0.666	0.395	0.422	0.408
100.90	2.147	1.611	1.643	100.28	0.666	0.395	0.421	0.408
103.52	2.149	1.610	1.643	102.90	0.668	0.395	0.422	0.409
107.46	2.155	1.606	1.642	106.84	0.674	0.399	0.423	0.411
62.39	2.160	1.597	1.615	61.77	0.679	0.408	0.450	0.429
94.34	2.168	1.595	1.625	93.72	0.687	0.411	0.440	0.425
83.80	2.179	1.583	1.613	83.18	0.698	0.423	0.451	0.437
94.85	2.187	1.576	1.604	94.23	0.706	0.430	0.461	0.446
85.83	2.195	1.563	1.593	85.21	0.714	0.443	0.472	0.457
98.48	2.206	1.548	1.581	97.85	0.725	0.457	0.484	0.470
86.43	2.216	1.535	1.567	85.81	0.735	0.471	0.498	0.484
95.29	2.227	1.522	1.552	94.67	0.746	0.484	0.513	0.499
91.89	2.238	1.508	1.536	91.27	0.757	0.498	0.529	0.514
82.40	2.254	1.493	1.521	81.78	0.773	0.513	0.544	0.528
92.85	2.270	1.471	1.505	92.23	0.789	0.535	0.560	0.547
94.11	2.275	1.453	1.484	93.49	0.794	0.553	0.581	0.567
97.38	2.283	1.446	1.474	96.76	0.802	0.560	0.591	0.575
102.10	2.289	1.441	1.474	101.48	0.808	0.564	0.591	0.578
105.99	2.291	1.442	1.471	105.37	0.810	0.564	0.594	0.579
108.97	2.291	1.442	1.471	108.35	0.810	0.564	0.594	0.579
104.14	2.294	1.441	1.470	103.52	0.813	0.565	0.595	0.580
88.23	2.300	1.423	1.451	87.61	0.819	0.583	0.614	0.598
76.98	2.308	1.404	1.436	76.36	0.827	0.602	0.629	0.615
112.32	2.313	1.388	1.417	111.70	0.832	0.617	0.648	0.633
66.22	2.318	1.372	1.398	65.60	0.837	0.633	0.667	0.650
97.50	2.329	1.362	1.389	96.88	0.848	0.644	0.676	0.660
84.92	2.340	1.347	1.373	84.30	0.859	0.659	0.692	0.675
80.72	2.348	1.331	1.357	80.10	0.867	0.675	0.708	0.691
107.00	2.351	1.315	1.338	106.38	0.870	0.691	0.727	0.709
78.26	2.359	1.293	1.317	77.64	0.878	0.713	0.748	0.730

Table A.18 Initial and zeroed readings for steel plate & oil test 2 (continued)

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
94.13	2.359	1.292	1.316	93.51	0.878	0.714	0.749	0.732
97.44	2.367	1.292	1.313	96.82	0.886	0.714	0.752	0.733
100.42	2.353	1.293	1.313	99.80	0.872	0.713	0.752	0.732
100.23	2.359	1.288	1.312	99.61	0.878	0.718	0.753	0.735
46.62	2.359	1.277	1.298	46.00	0.878	0.729	0.767	0.748
93.86	2.364	1.264	1.287	93.24	0.883	0.742	0.778	0.760
68.80	2.364	1.245	1.269	68.18	0.883	0.761	0.796	0.778
113.31	2.372	1.230	1.254	112.69	0.891	0.776	0.811	0.793
69.01	2.375	1.188	1.235	68.39	0.894	0.818	0.830	0.824
80.10	2.377	1.161	1.215	79.48	0.896	0.845	0.850	0.847
110.46	2.383	1.146	1.196	109.84	0.902	0.860	0.869	0.864
91.52	2.380	1.152	1.170	90.90	0.899	0.853	0.895	0.874
62.47	2.380	1.132	1.151	61.85	0.899	0.874	0.914	0.894
77.95	2.383	1.129	1.147	77.33	0.902	0.876	0.917	0.897
80.62	2.385	1.127	1.147	80.00	0.904	0.879	0.918	0.898
82.89	2.388	1.132	1.144	82.27	0.907	0.874	0.921	0.897

Table A.19 Initial and zeroed readings for steel plate & oil test 3

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
0.66	1.109	1.957	2.038	0.00	0.000	0.000	0.000	0.000
0.74	1.111	1.957	2.038	0.09	0.002	0.000	0.000	0.000
0.74	1.117	1.957	2.038	0.09	0.008	0.000	0.000	0.000
0.70	1.117	1.957	2.038	0.04	0.008	0.000	0.000	0.000
0.74	1.111	1.958	2.037	0.09	0.002	0.000	0.001	0.000
0.74	1.109	1.958	2.038	0.09	0.000	0.000	0.000	0.000
0.74	1.120	1.957	2.038	0.09	0.011	0.000	0.000	0.000
0.66	1.126	1.957	2.038	0.00	0.017	0.000	0.000	0.000
0.66	1.120	1.957	2.037	0.00	0.011	0.000	0.001	0.000
0.66	1.126	1.958	2.038	0.00	0.017	0.000	0.000	0.000
10.57	1.138	1.957	2.038	9.92	0.029	0.000	0.000	0.000
39.15	1.138	1.957	2.033	38.49	0.029	0.001	0.005	0.003
114.74	1.144	1.949	2.028	114.08	0.035	0.008	0.010	0.009
64.15	1.149	1.910	2.011	63.49	0.040	0.047	0.027	0.037
103.23	1.155	1.937	2.005	102.58	0.046	0.021	0.033	0.027
111.66	1.161	1.937	2.008	111.00	0.052	0.021	0.030	0.025
115.28	1.167	1.937	2.007	114.62	0.058	0.021	0.031	0.026
118.63	1.167	1.936	2.006	117.97	0.058	0.021	0.032	0.026
121.94	1.167	1.933	2.007	121.28	0.058	0.024	0.031	0.028
101.56	1.184	1.923	2.003	100.90	0.075	0.034	0.035	0.035
117.14	1.213	1.925	1.993	116.48	0.104	0.032	0.045	0.038
88.60	1.243	1.913	1.984	87.95	0.134	0.044	0.054	0.049
104.04	1.266	1.901	1.972	103.38	0.157	0.056	0.066	0.061
97.73	1.301	1.856	1.960	97.07	0.192	0.101	0.078	0.090
85.91	1.330	1.881	1.948	85.26	0.221	0.076	0.090	0.083
108.78	1.347	1.859	1.937	108.12	0.238	0.098	0.101	0.100
84.98	1.382	1.858	1.926	84.33	0.273	0.100	0.112	0.106
97.81	1.394	1.844	1.915	97.15	0.285	0.113	0.123	0.118
94.44	1.435	1.832	1.902	93.78	0.326	0.125	0.136	0.130
92.14	1.469	1.820	1.891	91.49	0.360	0.137	0.147	0.142
96.49	1.499	1.804	1.877	95.83	0.390	0.154	0.161	0.158
93.59	1.522	1.799	1.863	92.93	0.413	0.159	0.175	0.167
89.91	1.533	1.790	1.856	89.25	0.424	0.168	0.182	0.175
101.14	1.533	1.790	1.856	100.49	0.424	0.167	0.182	0.175
106.15	1.533	1.789	1.856	105.49	0.424	0.168	0.182	0.175
110.06	1.545	1.790	1.855	109.40	0.436	0.167	0.183	0.175
112.98	1.533	1.790	1.855	112.32	0.424	0.167	0.183	0.175
115.34	1.533	1.790	1.855	114.68	0.424	0.167	0.183	0.175
58.64	1.557	1.782	1.840	57.98	0.448	0.176	0.198	0.187
79.29	1.574	1.770	1.836	78.63	0.465	0.187	0.202	0.194
102.34	1.597	1.758	1.825	101.69	0.488	0.200	0.213	0.206
79.11	1.603	1.748	1.807	78.45	0.494	0.209	0.231	0.220
96.07	1.632	1.736	1.802	95.42	0.523	0.221	0.236	0.229

Table A.19 Initial and zeroed readings for steel plate & oil test 3 (continued)

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
80.97	1.650	1.723	1.786	80.31	0.541	0.235	0.252	0.243
93.30	1.661	1.714	1.776	92.64	0.552	0.244	0.262	0.253
80.18	1.679	1.689	1.763	79.52	0.570	0.268	0.275	0.271
84.34	1.708	1.683	1.746	83.68	0.599	0.274	0.292	0.283
86.51	1.720	1.664	1.727	85.86	0.611	0.293	0.311	0.302
80.45	1.749	1.652	1.713	79.79	0.640	0.305	0.325	0.315
94.85	1.749	1.645	1.706	94.20	0.640	0.312	0.332	0.322
98.89	1.749	1.649	1.709	98.23	0.640	0.308	0.329	0.319
102.49	1.766	1.649	1.709	101.83	0.657	0.309	0.329	0.319
105.37	1.766	1.649	1.709	104.71	0.657	0.308	0.329	0.319
110.27	1.760	1.649	1.710	109.61	0.651	0.309	0.328	0.319
82.77	1.789	1.636	1.698	82.11	0.680	0.321	0.340	0.330
97.96	1.795	1.626	1.686	97.30	0.686	0.331	0.352	0.342
79.02	1.824	1.611	1.671	78.37	0.715	0.347	0.367	0.357
97.44	1.830	1.598	1.652	96.78	0.721	0.360	0.386	0.373
83.41	1.842	1.583	1.641	82.75	0.733	0.374	0.397	0.386
86.41	1.859	1.567	1.629	85.75	0.750	0.390	0.409	0.400
89.37	1.888	1.553	1.613	88.71	0.779	0.404	0.425	0.415
84.96	1.877	1.538	1.597	84.30	0.768	0.419	0.441	0.430
89.47	1.906	1.522	1.578	88.82	0.797	0.435	0.460	0.447
83.99	1.929	1.504	1.559	83.33	0.820	0.454	0.479	0.467
82.96	1.952	1.496	1.552	82.30	0.843	0.461	0.486	0.474
85.13	1.964	1.491	1.550	84.47	0.855	0.466	0.488	0.477
87.03	1.970	1.491	1.548	86.37	0.861	0.466	0.490	0.478
88.87	1.970	1.492	1.548	88.22	0.861	0.465	0.490	0.478
90.63	1.982	1.492	1.548	89.97	0.873	0.465	0.490	0.478
93.92	1.987	1.491	1.548	93.26	0.878	0.466	0.490	0.478
94.34	1.987	1.480	1.536	93.68	0.878	0.477	0.502	0.489
79.79	1.993	1.465	1.521	79.13	0.884	0.493	0.517	0.505
92.23	2.005	1.450	1.506	91.57	0.896	0.507	0.532	0.520
78.09	2.011	1.435	1.490	77.43	0.902	0.523	0.548	0.535
91.63	2.022	1.419	1.475	90.97	0.913	0.538	0.563	0.551
96.26	2.028	1.406	1.462	95.60	0.919	0.551	0.576	0.564
86.87	2.034	1.392	1.446	86.21	0.925	0.565	0.592	0.578
85.15	2.040	1.376	1.428	84.49	0.931	0.581	0.610	0.595
90.05	2.057	1.360	1.415	89.40	0.948	0.597	0.623	0.610
86.97	2.057	1.342	1.397	86.31	0.948	0.615	0.641	0.628
84.14	2.051	1.328	1.381	83.48	0.942	0.629	0.657	0.643
93.45	2.051	1.326	1.381	92.79	0.942	0.631	0.657	0.644
97.23	2.046	1.324	1.379	96.58	0.937	0.633	0.659	0.646
100.25	2.051	1.325	1.379	99.60	0.942	0.632	0.659	0.645
102.90	2.051	1.326	1.378	102.25	0.942	0.632	0.660	0.646
105.08	2.051	1.326	1.377	104.42	0.942	0.632	0.661	0.646

Table A.19 Initial and zeroed readings for steel plate & oil test 3 (continued)

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
126.45	2.046	1.320	1.376	125.79	0.937	0.637	0.662	0.650
103.83	2.051	1.313	1.368	103.18	0.942	0.644	0.670	0.657
86.83	2.040	1.303	1.356	86.17	0.931	0.654	0.682	0.668
95.54	2.046	1.293	1.342	94.88	0.937	0.664	0.696	0.680
81.24	2.057	1.259	1.324	80.58	0.948	0.698	0.714	0.706
84.92	2.051	1.212	1.309	84.26	0.942	0.745	0.729	0.737
85.29	2.040	1.226	1.294	84.64	0.931	0.731	0.744	0.737
79.96	2.046	1.220	1.281	79.30	0.937	0.737	0.757	0.747
79.96	2.046	1.159	1.266	79.30	0.937	0.798	0.772	0.785
84.45	2.046	1.196	1.252	83.79	0.937	0.761	0.786	0.773
79.15	2.063	1.118	1.236	78.49	0.954	0.839	0.802	0.821
77.06	2.063	1.162	1.224	76.40	0.954	0.795	0.814	0.805
86.95	2.057	1.078	1.223	86.29	0.948	0.879	0.815	0.847
90.69	2.057	1.082	1.219	90.04	0.948	0.875	0.819	0.847
93.51	2.075	1.162	1.219	92.85	0.966	0.795	0.819	0.807
96.18	2.075	1.166	1.219	95.52	0.966	0.791	0.819	0.805
98.41	2.080	1.166	1.219	97.75	0.971	0.791	0.819	0.805
81.24	2.080	1.139	1.204	80.58	0.971	0.819	0.834	0.826
81.47	2.098	1.088	1.183	80.81	0.989	0.869	0.855	0.862
98.39	2.092	1.088	1.164	97.73	0.983	0.869	0.874	0.872
78.38	2.092	1.024	1.144	77.72	0.983	0.933	0.894	0.914
74.78	2.104	1.068	1.128	74.12	0.995	0.889	0.910	0.900
87.71	2.104	1.007	1.111	87.06	0.995	0.951	0.927	0.939
82.85	2.110	0.998	1.100	82.19	1.001	0.959	0.938	0.949
84.53	2.121	1.040	1.083	83.87	1.012	0.918	0.955	0.936
68.00	2.127	1.021	1.068	67.34	1.018	0.936	0.970	0.953
89.95	2.139	1.022	1.066	89.29	1.030	0.935	0.972	0.953
93.32	2.144	1.021	1.066	92.66	1.035	0.936	0.972	0.954
96.43	2.144	1.022	1.065	95.77	1.035	0.936	0.973	0.954
98.97	2.144	1.022	1.064	98.31	1.035	0.936	0.974	0.955
101.14	2.144	1.021	1.064	100.49	1.035	0.936	0.974	0.955
47.10	2.162	1.010	1.051	46.44	1.053	0.948	0.987	0.967
78.32	2.150	0.991	1.037	77.66	1.041	0.967	1.001	0.984
87.22	2.162	0.974	1.021	86.56	1.053	0.983	1.017	1.000
80.82	2.162	0.945	1.005	80.17	1.053	1.012	1.033	1.022
81.78	2.162	0.945	0.992	81.12	1.053	1.013	1.046	1.029
85.58	2.179	0.918	0.978	84.93	1.070	1.040	1.060	1.050
83.10	2.203	0.926	0.965	82.44	1.094	1.031	1.073	1.052
85.46	2.197	0.911	0.951	84.80	1.088	1.046	1.087	1.066
84.09	2.232	0.895	0.935	83.44	1.123	1.062	1.103	1.083
81.13	2.226	0.875	0.917	80.48	1.117	1.083	1.121	1.102
80.45	2.238	0.868	0.905	79.79	1.129	1.090	1.133	1.111
92.00	2.261	0.864	0.906	91.34	1.152	1.094	1.132	1.113

Table A.19 Initial and zeroed readings for steel plate & oil test 3 (continued)

Initial Readings				Zeroed Readings				
Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Load (lb)	LVDT (in)	Pot1 (in)	Pot2 (in)	Avg. Pot (in)
95.89	2.243	0.866	0.905	95.23	1.134	1.092	1.133	1.112
99.45	2.243	0.866	0.903	98.79	1.134	1.092	1.135	1.113
102.22	2.255	0.865	0.903	101.56	1.146	1.092	1.135	1.113
104.83	2.261	0.856	0.903	104.17	1.152	1.102	1.135	1.118
40.66	2.261	0.847	0.889	40.00	1.152	1.110	1.149	1.129
71.76	2.261	0.843	0.880	71.10	1.152	1.115	1.158	1.137
94.77	2.278	0.826	0.865	94.11	1.169	1.131	1.173	1.152
76.83	2.284	0.809	0.848	76.17	1.175	1.149	1.190	1.169
93.98	2.290	0.796	0.833	93.33	1.181	1.161	1.205	1.183
79.64	2.313	0.780	0.818	78.99	1.204	1.177	1.220	1.199
86.97	2.325	0.766	0.802	86.31	1.216	1.191	1.236	1.213
85.87	2.336	0.752	0.787	85.22	1.227	1.206	1.251	1.228
82.48	2.354	0.736	0.770	81.82	1.245	1.222	1.268	1.245
86.08	2.348	0.721	0.755	85.42	1.239	1.237	1.283	1.260
80.60	2.377	0.707	0.741	79.94	1.268	1.250	1.297	1.274
92.43	2.377	0.706	0.739	91.77	1.268	1.251	1.299	1.275
97.69	2.383	0.706	0.740	97.03	1.274	1.252	1.298	1.275
101.62	2.377	0.706	0.738	100.96	1.268	1.251	1.300	1.276
104.87	2.389	0.705	0.737	104.21	1.280	1.253	1.301	1.277
107.64	2.395	0.704	0.736	106.98	1.286	1.253	1.302	1.277
126.76	2.395	0.701	0.734	126.10	1.286	1.257	1.304	1.280
94.40	2.400	0.684	0.717	93.74	1.291	1.273	1.321	1.297
81.36	2.406	0.668	0.698	80.70	1.297	1.290	1.341	1.315
84.16	2.424	0.649	0.678	83.50	1.315	1.309	1.360	1.334
104.93	2.430	0.629	0.662	104.27	1.321	1.328	1.376	1.352
72.07	2.447	0.610	0.641	71.41	1.338	1.347	1.397	1.372
85.69	2.459	0.595	0.626	85.03	1.350	1.363	1.412	1.387
99.65	2.476	0.580	0.610	99.00	1.367	1.377	1.428	1.403
73.75	2.494	0.561	0.590	73.09	1.385	1.396	1.448	1.422
78.36	2.505	0.547	0.576	77.70	1.396	1.410	1.462	1.436
87.18	2.517	0.546	0.572	86.52	1.408	1.411	1.466	1.439
92.89	2.523	0.546	0.572	92.23	1.414	1.412	1.466	1.439
97.32	2.528	0.543	0.572	96.66	1.419	1.414	1.466	1.440
99.84	2.523	0.543	0.571	99.18	1.414	1.414	1.467	1.441
101.43	2.528	0.542	0.569	100.78	1.419	1.415	1.469	1.442

APPENDIX B

FIELD SHEETS FOR DEMEC READINGS AND LENGTH CHANGE

This Appendix contains DEMEC readings and length change measurement field sheets for the 12 girders tested for the field test experiments. These field sheets were used to create the strain tables in Appendix F.

Measurements for strain and girder slide were taken on both the north and south sides of the girders, on both the east and west ends. All strain values were compression strain and were designated a "-" value. Girder slide was the measured movement exhibited by the ends of the girders. Movement in the west direction was given a "+" value and movement in the east direction was given a "-" value.

The initial length (L_o) was the center to center spacing of the epoxy bonded steel stubs. This distance was assumed to be 10 in. for the calculation of strain values given in tables in Chapter VI. Though the actual distance varied by $\pm$ the initial DEMEC gauge reading (L_o DEMEC), that difference wasn't significant enough to vary strain values. L_o DEMEC was the value on the DEMEC strain gauge before the prestressing strands were cut. $L_{1\ Bed}$ was the value on the DEMEC strain gauge after the prestressing strands were cut while the girders were on the casting bed. $L_{1\ Move}$ was the value on the DEMEC strain gauge after the girders were moved off the casting bed.

Date: 9/28
Time: 10:30 – 1:30
Students: HURFF, FELIX, BUWVA, ME

Beam	Designation	Length (ft)	Weight (ton)	Prestress (kip)	# Strands	Total Force
1	17-13.1					
2	17-14.1					
3	17-15.1					

	Beam			L_o (venier)	L_o (DEMEC)	L_1 Bed	L_1 Move	ε_{bed}	ε_{move}	Avg ε_{bed}	Avg ε_{move}	TL	Girder Slide
	1	North Side	East	2	0.0302	0.0326	0.0367	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!		+ 1 7/64
3	1	North Side	West	2	-0.0064	-0.0031	0.0008	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	-	0
	1	South Side	East	1	0.0178	0.0220	0.0269	#DIV/0!	#DIV/0!	-	-		+ 1 24/64
	1	South Side	West	1	-0.0118	-0.0081	-0.0068	#DIV/0!	#DIV/0!	-	-	-	0
	2	North Side	East	2	-0.0292	-0.0206	-0.0168	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!		+ 1/64
2	2	North Side	West	2	-0.0061	-0.0022	-0.0009	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	-	- 1 40/64
	2	South Side	East	1	-0.0136	-0.0065	-0.0085	#DIV/0!	#DIV/0!	-	-		+ 60/64
	2	South Side	West	1	-0.0213	-0.0161	-0.0170	#DIV/0!	#DIV/0!	-	-	-	- 1 44/64
	3	North Side	East	2	-0.0180	-0.0157	-0.0130	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!		+ 1 1/64
1	3	North Side	West	2	-0.0193	-0.0178	-0.0166	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	-	- 11/64
	3	South Side	East	1	-0.0165	-0.0132	-0.0116	#DIV/0!	#DIV/0!	-	-		+ 1 7/64
	3	South Side	West	1	-0.0036	0.0009	0.0033	#DIV/0!	#DIV/0!	-	-	-	- 11/64

PADS Beam 1 NE → SE → SW → NW
2
3

*** Note:

1.) West movement (+)
2.) East movement (-)
3.) Epoxy used to glue steel spacers on concrete
4.) Venier Calipers used to measure initial lengths
5.) DEMEC gauge used to measure initial and change in lengths
6.) End Treatment: Beam 1 : TEFLON PAD
Beam 2 : TEFLON PAD
Beam 3 : TEFLON PAD

BAR 2 – NORTH
BAR 1 – SOUTH

10/2
BEAM 1 – WAX
BEAM 2 – WAX (DEGREASED OIL FIRST)
BEAM 3 – NONE

Figure B.1 DEMEC and length change field sheet pad1, pad2, and pad3

INITIAL DEMEC = -0.1478

Date: 10/12
Time:
Students: HUEPF, FELIX, BUNK, ME

Beam	Designation	Length (ft)	Weight (ton)	Prestress (kip)	# Strands	Total Force
1	17-16.1					
2	17-10.5					
3	17-11.5					

+0.115

Beam	-		L_o (venier)	L_o (DEMEC)	L_1 Bed	L_1 Move	ε_{bed}	ε_{move}	Avg ε_{bed}	Avg ε_{move}	TL	Girder Slide
1	North Side	East	BAR 1	-0.0111	-0.0078	-0.0061	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!		+ 38/64
1	North Side	West	1	-0.0001	0.0054	0.0066	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	-	- 24/64
1	South Side	East	2	-0.0066	-0.0040	-0.0022	#DIV/0!	#DIV/0!	-	-		+ 46/64
1	South Side	West	2	-0.0026	0.0003	0.0015	#DIV/0!	#DIV/0!	-	-	-	- 2 4/64
2	North Side	East	1	0.0117	0.0149	0.0161	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!		+ 2 4/64
2	North Side	West	1	-0.0017	-0.0043	-0.0035	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	-	+ 2 58/64
2	South Side	East	2	-0.0112	-0.0070	-0.0062	#DIV/0!	#DIV/0!	-	-		+ 2 4/64
2	South Side	West	2	-0.0376	-0.0255	-0.0233	#DIV/0!	#DIV/0!	-	-	-	+ 3 38/64
3	North Side	East	1	-0.0028	0.0018	0.0031	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!		+ 14/64
3	North Side	West	1	0.0075	0.0099	0.0111	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	-	- 38/64
3	South Side	East	2	-0.0165	-0.0131	-0.0112	#DIV/0!	#DIV/0!	-	-		+ 24/64
3	South Side	West	2	-0.0179	-0.0104	-0.0093	#DIV/0!	#DIV/0!	-	-	-	- 38/64

*** Note:

1.) West movement (+)
2.) East movement (-)
3.) Epoxy used to glue steel spacers on concrete
4.) Venier Calipers used to measure initial lengths
5.) DEMEC gauge used to measure initial and change in lengths
6.) End Treatment: Beam 1 : WAX
Beam 2 : WAX
Beam 3 : NONE

DEMEC
(-) SMALLER
(+) BIGGER

(x3?)
NE → SE → SW → NW

BEAM 1

PICS → 2
3

Figure B.2 DEMEC and Length Change Field Sheet Wax1, Wax2, and None1

(INITIAL DEMEC = -0.1537

Date: 10/5
Time: 8:00 - 2:00
Students: HURFF, KIM, BUNYA, MG

Beam	Designation	Length (ft)	Weight (ton)	Prestress (kip)	# Strands	Total Force
1						
2						
3						

Beam			L_o (venier)	L_o (DEMEC)	L_1 Bed	L_1 Move	ε_{bed}	ε_{move}	Avg ε_{bed}	Avg ε_{move}	TL	Girder Slide
1	North Side	East	2	-0.0080	-0.0031	-0.0129	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!		+30/64
1	North Side	West	2	-0.0187	-0.0119	-0.0108	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	-	-30/64
1	South Side	East	1	-0.0010	0.0032	0.0035	#DIV/0!	#DIV/0!	-	-		+36/64
1	South Side	West	1	-0.0155	-0.0088	-0.0078	#DIV/0!	#DIV/0!	-	-	-	-34/64
2	North Side	East	2	-0.0143	-0.0121	-0.0088	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!		+42/64
2	North Side	West	2	-0.0122	-0.0068	-0.0018	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	-	-37/64
2	South Side	East	1	-0.0065	-0.0021	0.0008	#DIV/0!	#DIV/0!	-	-		+42/64
2	South Side	West	1	-0.0060	-0.0022	0.0010	#DIV/0!	#DIV/0!	-	-	-	-34/64
3	North Side	East	2	-0.0182	-0.0091	-0.0039	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!		+50/64
3	North Side	West	2	-0.0170	-0.0078	-0.0020	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	-	-50/64
3	South Side	East	1	-0.0067	-0.0020	-0.0011	#DIV/0!	#DIV/0!	-	-		+64/64
3	South Side	West	1	-0.0057	0.0004	0.0012	#DIV/0!	#DIV/0!	-	-	-	-50/64

*** Note:
1.) West movement (+)
2.) East movement (-)
3.) Epoxy used to glue steel spacers on concrete
4.) Venier Calipers used to measure initial lengths
5.) DEMEC gauge used to measure initial and change in lengths
6.) End Treatment: ST ∠ Beam 1 : 19-19.5
NONE Beam 2 : 19-20.1
ST ∠ Beam 3 : 19-20.2

PICS: GLUING MARKER BEAM 3 NW → SW → SE → NE

2
1

BEAM 2 SW x2
NW

BEAM 1 WEST END 1" PLY ADD'L
EAST 1/8 x2
WEST x2
EAST x2
BEAM 3 EAST x2

17-13.1 NE PATCHED CORNER

Figure B.3 DEMEC and Length Change Field Sheet Angle1, None2, and Plate1

INITIAL DEMEC = -0.1540

Date: 1/9
Time:
Students: FELIX, ME, BUNYA

Beam	Designation	Length (ft)	Weight (ton)	Prestress (kip)	# Strands	Total Force
1	19-20.3					
2	19-20.4					
3	19-20.5	125'-6"				

Beam			L_o (venier)	L_o (DEMEC)	L_1 Bed	L_1 Move	ε_{bed}	ε_{move}	Avg ε_{bed}	Avg ε_{move}	TL	Girder Slide
1	North Side	East	1	0.0262	0.0318	0.0327	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!		-1 35/64
1	North Side	West	1	0.0185	0.0241	0.0259	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	-	+2 30/64
1	South Side	East	2	0.0280	0.0345	0.0362	#DIV/0!	#DIV/0!	-	-		-1 30/64
1	South Side	West	2	0.0173	0.0227	0.0240	#DIV/0!	#DIV/0!	-	-	-	-2 30/64
2	North Side	East	1	0.0242	0.0280	0.0322	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!		+2 12/64
2	North Side	West	1	0.0123	0.0172	0.0210	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	-	+1 2/64
2	South Side	East	2	0.0217	0.0274	0.0318	#DIV/0!	#DIV/0!	-	-		+2 12/64
2	South Side	West	2	0.0094	0.0160	0.0202	#DIV/0!	#DIV/0!	-	-	-	+1 2/64
3	North Side	East	1	0.0151	0.0208	0.0216	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!		+6 8/64
3	North Side	West	1	0.0189	0.0255	0.0263	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	-	-3 1/64
3	South Side	East	2	0.0243	0.0326	0.0340	#DIV/0!	#DIV/0!	-	-		+6 8/64
3	South Side	West	2	0.0276	0.0330	0.0341	#DIV/0!	#DIV/0!	-	-	-	-2 1/64

*** Note:

1.) West movement (+)
2.) East movement (-)
3.) Epoxy used to glue steel spacers on concrete
4.) Venier Calipers used to measure initial lengths
5.) DEMEC gauge used to measure initial and change in lengths
6.) End Treatment: Beam 1 : 19-20.3 STEEL PL
Beam 2 : 19-20.4 TEFLON PAD
Beam 3 : 19-20.5 ST 2

PICS : BEAM 3 NW → SW → SE → NE
2
1

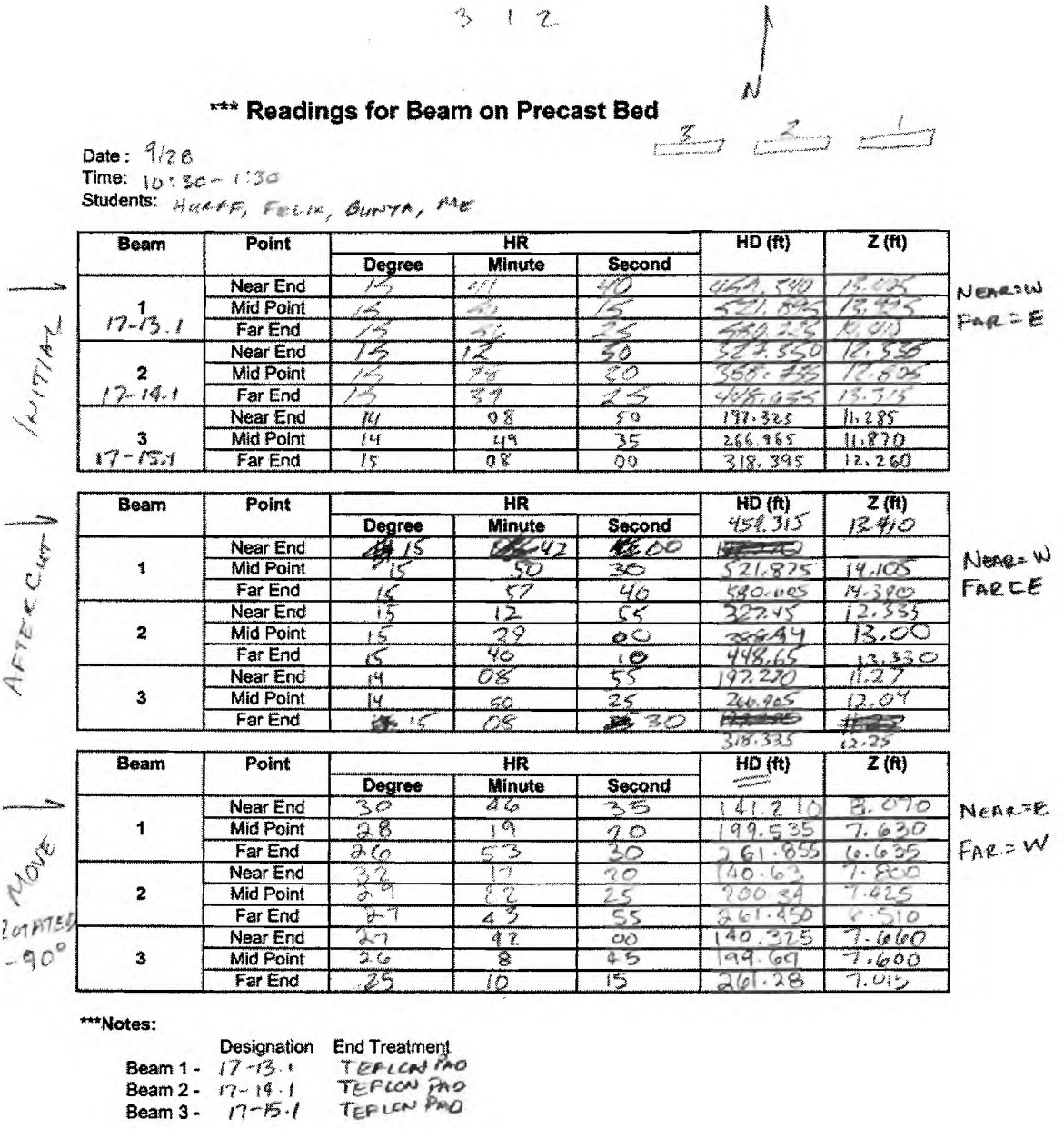
BEAM 2 SE
3 SW → NW
1 SW → SE

Figure B.4 DEMEC and Length Change Field Sheet Plate2, Pad4, and Angle2

APPENDIX C

FIELD SHEETS FOR TOTAL STATION READIINGS

This Appendix contains Total Station field sheets for the 12 girders tested for the field test experiments. The total station instrument was zeroed at an arbitrary fixed point. A prism rod was held at each of the three locations from which horizontal angle (HR), horizontal distance (HD), and elevation (Z) were taken before the prestressing strands were cut, after the prestressing strands were cut while the girders were still on the casting bed, and after the girders were moved off of the casting bed with respect to that arbitrary fixed point. The fixed point was the same for the first two readings and a new point was chosen when the girders were removed off of the casting bed, depending on the location it was moved to at the plant. Field sheets presented in Appendix C were used to create tables in Appendix G.



3 1 2

N

3 2 1

*** Readings for Beam on Precast Bed

Date: 9/28
Time: 10:30 - 1:30
Students: HARFF, FELIX, BUNYA, ME

INITIAL

Beam	Point	HR			HD (ft)	Z (ft)	
		Degree	Minute	Second			
1 17-13.1	Near End	15	11	40	464.540	12.035	NEAR=W
	Mid Point	14	20	15	451.895	13.995	FAR=E
	Far End	15	21	25	484.225	14.013	
2 17-14.1	Near End	13	12	30	322.550	12.535	
	Mid Point	14	29	20	358.185	12.805	
	Far End	13	39	25	406.065	13.515	
3 17-15.1	Near End	11	08	50	197.325	11.285	
	Mid Point	14	49	35	266.965	11.870	
	Far End	15	08	00	318.395	12.260	

AFTER CUT

Beam	Point	HR			HD (ft) 459.315	Z (ft) 12.410	
		Degree	Minute	Second			
1	Near End	~~14~~ 15	~~06~~ 42	~~55~~ 00	~~[illegible]~~		NEAR=W
	Mid Point	15	50	30	521.875	14.105	FAR=E
	Far End	16	57	40	580.005	14.390	
2	Near End	15	12	55	327.45	12.335	
	Mid Point	15	29	00	~~398.44~~	13.00	
	Far End	15	40	10	448.65	~~13.330~~	
3	Near End	14	08	55	197.270	11.27	
	Mid Point	14	50	25	266.905	12.04	
	Far End	~~15~~ 15	08	~~35~~ 30	~~[illegible]~~ 318.335	~~[illegible]~~ 12.23	

MOVE ROTATED -90°

Beam	Point	HR			HD (ft)	Z (ft)	
		Degree	Minute	Second			
1	Near End	30	46	35	141.210	8.090	NEAR=E
	Mid Point	28	19	20	199.535	7.630	FAR=W
	Far End	26	53	30	261.855	6.635	
2	Near End	32	17	20	140.62	7.820	
	Mid Point	29	22	25	200.34	7.625	
	Far End	27	43	55	261.450	7.510	
3	Near End	27	42	00	140.325	7.660	
	Mid Point	26	8	45	199.69	7.600	
	Far End	25	10	15	261.28	7.015	

***Notes:

	Designation	End Treatment
Beam 1 -	17-13.1	TEFLON PAD
Beam 2 -	17-14.1	TEFLON PAD
Beam 3 -	17-15.1	TEFLON PAD

Figure C.1 Total station field sheet pad1, pad2, and pad3

***** Readings for Beam on Precast Bed**

F M N F M N F M N

Date : 10/2
Time:
Students: HUFF, FELIX, BUNYA, ME

NEAR = E
FAR = W

INITIAL

Beam	Point	HR			HD (ft)	Z (ft)
		Degree	Minute	Second		
1	Near End	38	20	05	44.815	8.620
	Mid Point	24	45	55	104.230	8.100
	Far End	21	02	55	165.800	7.605
2	Near End	19	44	55	183.745	9.740
	Mid Point	18	45	00	245.305	10.275
	Far End	18	09	50	306.840	10.735
3	Near End	18	05	45	318.290	10.835
	Mid Point	17	43	30	378.605	11.490
	Far End	17	28	40	441.990	11.925

AFTER CUT

Beam	Point	HR			HD (ft)	Z (ft)
		Degree	Minute	Second		
1	Near End	38	19	30	44.830	8.615
	Mid Point	24	43	30	104.150	8.285
	Far End	21	03	05	165.780	7.595
2	Near End	19	44	40	183.720	9.730
	Mid Point	18	44	45	245.235	10.455
	Far End	18	09	55	306.805	10.720
3	Near End	18	05	30	318.250	10.855
	Mid Point	17	45	00	378.550	11.605
	Far End	17	28	55	441.540	11.970

MOVE

Beam	Point	HR			HD (ft)	Z (ft)
		Degree	Minute	Second		
1	Near End	41	38	05	142.835	7.850
	Mid Point	39	47	40	202.230	6.810
	Far End	38	42	20	263.905	5.225
2	Near End	32	05	30	138.750	8.415
	Mid Point	33	15	15	200.305	7.000
	Far End	33	54	10	261.990	5.000
3	Near End	33	49	20	137.965	8.365
	Mid Point	34	23	10	198.225	6.980
	Far End	34	40	15	261.290	5.050

*****Notes:**

	Designation	End Treatment
Beam 1 -	17-16 1	WAX
Beam 2 -	17-18 5	WAX
Beam 3 -	17-11 5	NONE

Figure C.2 Total station field sheet wax1, wax2, and none1

***** Readings for Beam on Precast Bed**

Date: 10/6
Time: 2:00
Students: HUAPP, ME, FELIX, [illegible], JOHAN

NEAR = E
FAR = W

INITIAL

Beam	Point	HR			HD (ft)	Z (ft)
		Degree	Minute	Second		
1	Near End	36	08	05	89.695	8.780
	Mid Point	26	58	00	198.280	8.245
	Far End	22	55	05	208.620	7.860
2	Near End	22	22	05	220.780	7.725
	Mid Point	20	24	55	281.935	7.200
	Far End	19	07	30	342.790	6.790
3	Near End	18	56	25	355.605	6.625
	Mid Point	18	07	55	415.530	6.100
	Far End	17	29	45	478.575	5.700

AFTER CUT

Beam	Point	HR			HD (ft)	Z (ft)
		Degree	Minute	Second		
1	Near End	36	08	55	89.695	8.815
	Mid Point	26	58	20	198.225	8.985
	Far End	22	55	00	208.630	7.845
2	Near End	22	22	25	220.745	7.725
	Mid Point	20	24	10	281.845	7.170
	Far End	19	07	35	342.790	6.765
3	Near End	18	56	00	355.605	6.610
	Mid Point	18	07	45	415.490	6.340
	Far End	17	29	15	478.205	5.915

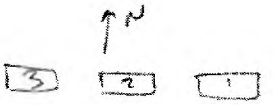
MOVE

Beam	Point	HR			HD (ft)	Z (ft)
		Degree	Minute	Second		
1	Near End	16	01	40	359.190	6.080
	Mid Point	16	05	40	419.130	5.770
	Far End	16	10	10	482.145	4.595
2	Near End	15	33	25	542.200	7.440
	Mid Point	15	37	10	602.935	6.995
	Far End	15	43	10	666.335	6.030
3	Near End	26	14	30	89.750	9.105
	Mid Point	22	30	25	150.470	8.690
	Far End	20	50	35	217.110	7.705

***Notes:

	Designation	End Treatment
Beam 1 -	19-19.5	ST L
Beam 2 -	19-20?	NONE
Beam 3 -	19-20.2	ST L

Figure C.3 Total station field sheet angle1, none2, and plate1



***** Readings for Beam on Precast Bed**

Date : 10/9
Time: 10:00 - 2:00
Students: FELIX, ME, BURKA

NEAR = E
FAR = W

INITIAL

Beam	Point	HR			HD (ft)	Z (ft)
		Degree	Minute	Second		
1	Near End	36	09	55	89.645	7.450
	Mid Point	26	51	00	149.020	6.925
	Far End	22	54	40	208.905	6.465
2	Near End	22	22	25	220.980	6.320
	Mid Point	20	23	40	287.250	5.805
	Far End	19	06	05	343.240	5.375
3	Near End	18	56	20	355.845	5.240
	Mid Point	18	05	05	417.370	4.720
	Far End	17	29	00	478.520	4.265

AFTER CUT

Beam	Point	HR			HD (ft)	Z (ft)
		Degree	Minute	Second		
1	Near End	36	09	35	89.365	7.475
	Mid Point	24	51	30	146.705	7.165
	Far End	22	54	35	208.940	6.080
2	Near End	22	22	00	221.215	6.330
	Mid Point	20	23	20	282.350	6.025
	Far End	19	06	35	345.945	5.545
3	Near End	18	56	30	357.580	5.410
	Mid Point	18	05	10	417.460	4.935
	Far End	17	29	20	478.505	4.260

MOVE

Beam	Point	HR			HD (ft)	Z (ft)
		Degree	Minute	Second		
1	Near End					
	Mid Point					
	Far End					
2	Near End	29	16	40	83.375	12.250
	Mid Point	29	10	15	144.850	12.350
	Far End	29	05	10	206.960	11.740
3	Near End	28	28	30	71.160	9.680
	Mid Point	28	42	35	132.475	9.880
	Far End	28	47	35	194.280	9.595

*****Notes:**

	Designation	End Treatment
Beam 1 -	19-203	ST R
Beam 2 -	19-204	TEFLON PAD
Beam 3 -	19-205	ST L

Figure C.4 Total station field sheet plate2, pad4, and angle2

APPENDIX D

FIELD SHEETS FOR STRAND TENSIONING DATA

This Appendix contains strand tensioning field data sheets for the 12 girders tested for the field test experiments. These values were summed together and used to create Table H.1 in Appendix H. The strand orientation changed slightly for each girder cross section. Each cross section followed the layout in Figure D.1

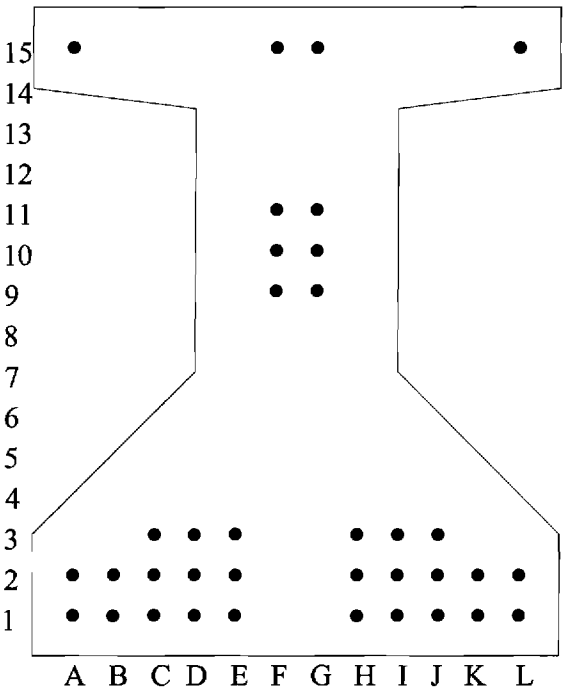
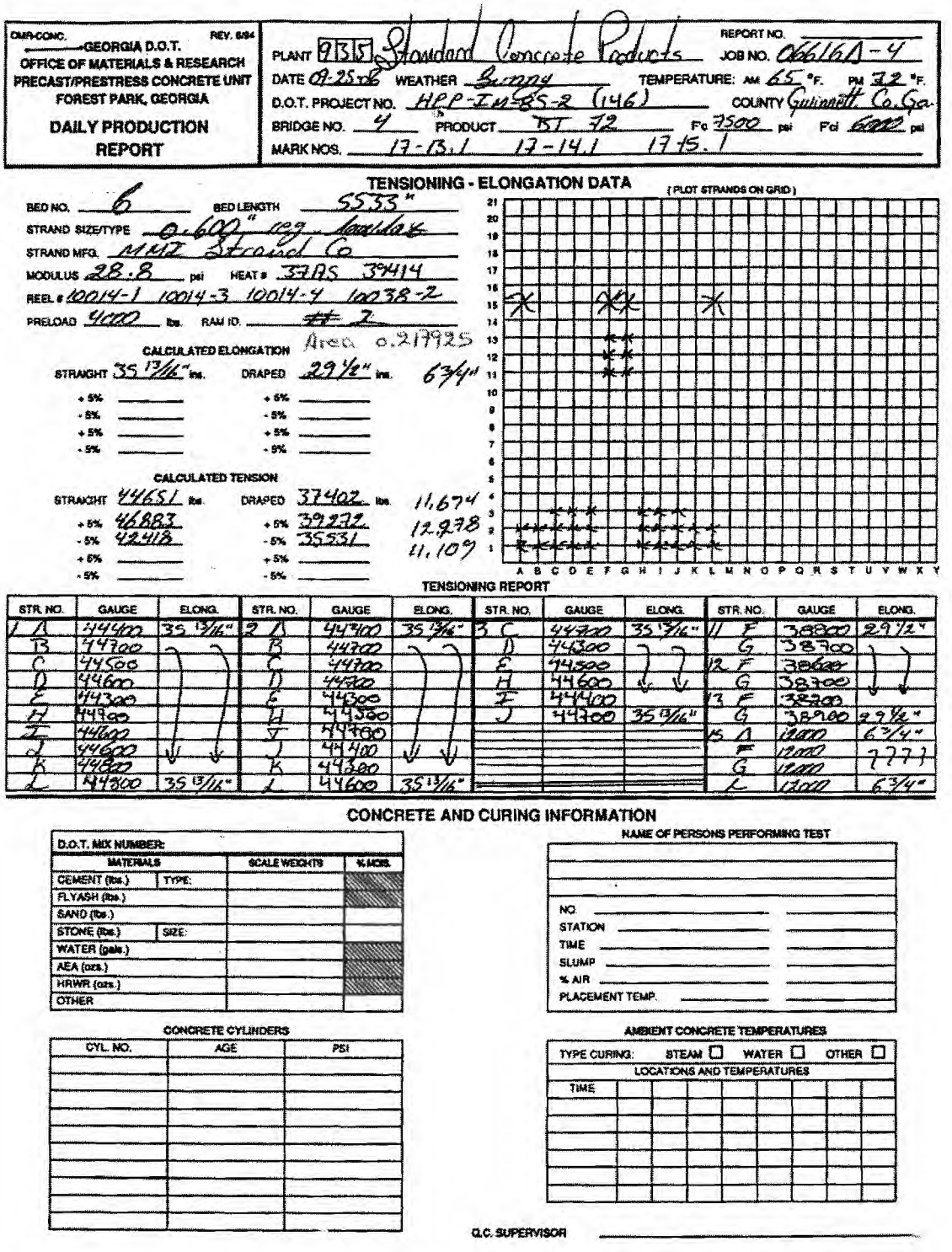


Figure D.1 Strand layout in cross section



DMR-CONC. REV. 6/94

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FOREST PARK, GEORGIA

DAILY PRODUCTION REPORT

PLANT 935 Standard Concrete Products — REPORT NO. — JOB NO. 0661615-4
DATE 9-25-06 WEATHER Sunny — TEMPERATURE: AM 65 °F. PM 72 °F.
D.O.T. PROJECT NO. HPP-IM-85-2 (146) — COUNTY Gwinnett Co. Ga.
BRIDGE NO. 4 — PRODUCT BT 72 — F'c 7500 psi — F'ci 6000 psi
MARK NOS. 17-13.1 17-14.1 17-15.1

TENSIONING - ELONGATION DATA

BED NO. 6 — BED LENGTH 555.53"
STRAND SIZE/TYPE 0.600" 1x7 Low Lax
STRAND MFG. NMI Strand Co
MODULUS 28.8 psi — HEAT # 37A5 39414
REEL # 10014-1 10014-3 10014-4 10038-2
PRELOAD 4000 lbs. — RAM ID. #2

CALCULATED ELONGATION — Area 0.21925

	STRAIGHT	DRAPED	
	35 13/16" ins.	29 1/2" ins.	6 3/4"
+ 5%			
- 5%			
+ 5%			
- 5%			

CALCULATED TENSION

	STRAIGHT	DRAPED	
	44651 lbs.	37402 lbs.	11,674
+ 5%	46883	39272	12,278
- 5%	42418	35531	11,109
+ 5%			
- 5%			

(PLOT STRANDS ON GRID)

TENSIONING REPORT

STR. NO.	GAUGE	ELONG.	STR. NO.	GAUGE	ELONG.	STR. NO.	GAUGE	ELONG.	STR. NO.	GAUGE	ELONG.
1 A	44400	35 13/16"	2 A	44700	35 13/16"	3 C	44700	35 13/16"	11 F	38800	29 1/2"
B	44700		B	44700		D	44300		G	38700	
C	44500		C	44700		E	44300		12 F	38600	
D	44600		D	44700		H	44600		G	38300	
E	44300		E	44300		J	44400		13 F	38200	
H	44900		H	44300		J	44700	35 13/16"	G	38900	29 1/2"
J	44600		J	44700					15 A	12000	6 3/4"
J	44600		J	44400					F	12000	7777
K	44800		K	44300					G	12000	
L	44300	35 13/16"	L	44600	35 13/16"				L	12000	6 3/4"

CONCRETE AND CURING INFORMATION

D.O.T. MIX NUMBER:

MATERIALS		SCALE WEIGHTS	% MOIS.
CEMENT (lbs.)	TYPE:		
FLYASH (lbs.)			
SAND (lbs.)			
STONE (lbs.)	SIZE:		
WATER (gals.)			
AEA (ozs.)			
HRWR (ozs.)			
OTHER			

NAME OF PERSONS PERFORMING TEST

NO.
STATION
TIME
SLUMP
% AIR
PLACEMENT TEMP.

CONCRETE CYLINDERS

CYL. NO.	AGE	PSI

AMBIENT CONCRETE TEMPERATURES

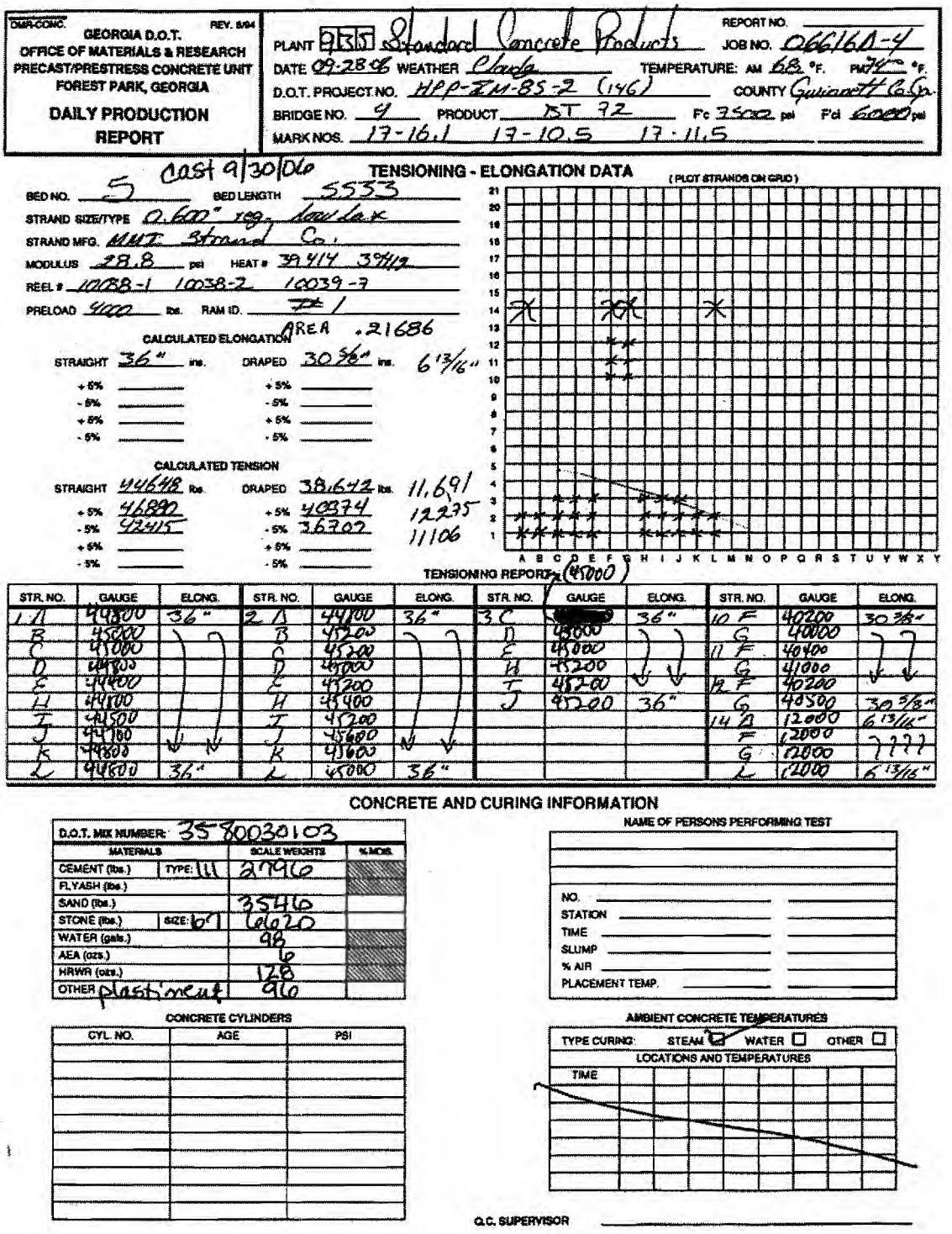
TYPE CURING: STEAM ☐ WATER ☐ OTHER ☐

LOCATIONS AND TEMPERATURES

TIME								

Q.C. SUPERVISOR

Figure D.2 Strand tensioning data field sheets pad1, pad2, and pad3



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DAILY PRODUCTION REPORT

PLANT Standard Concrete Products — REPORT NO. — JOB NO. 066160-4
DATE 09-28-06 WEATHER Cloudy — TEMPERATURE: AM 68 °F. PM 74 °F.
D.O.T. PROJECT NO. HPP-ZM-85-2 (146) — COUNTY Gwinnett Co. Ga.
BRIDGE NO. 4 — PRODUCT 78 ST 72 — F'c 7500 psi — F'ci 6000 psi
MARK NOS. 17-16.1 17-10.5 17-11.5

Cast 9/30/06

BED NO. 5 — BED LENGTH 5533
STRAND SIZE/TYPE 0.600" 199, low lax
STRAND MFG. MMT Strand Co.
MODULUS 28.8 psi — HEAT # 39414 39412
REEL # 10088-1 10038-2 10039-7
PRELOAD 4000 lbs. — RAM ID. #1

TENSIONING - ELONGATION DATA (PLOT STRANDS ON GRID)

CALCULATED ELONGATION — AREA .21686

	STRAIGHT	DRAPED	
	36" ins.	30 5/16" ins.	6 13/16"
+5%		+5%	
-5%		-5%	
+5%		+5%	
-5%		-5%	

CALCULATED TENSION

	STRAIGHT	DRAPED	
	44648 lbs.	38,642 lbs.	11,691
+5%	46880	+5% 40574	12275
-5%	42415	-5% 36702	11106
+5%		+5%	
-5%		-5%	

TENSIONING REPORT (45000)

STR. NO.	GAUGE	ELONG.	STR. NO.	GAUGE	ELONG.	STR. NO.	GAUGE	ELONG.	STR. NO.	GAUGE	ELONG.
1 A	44800	36"	2 A	44700	36"	3 C	[illegible]	36"	10 F	40200	30 3/8"
B	45000		B	45200		D	45000		G	40000	
C	45000		C	45200		E	45000		11 F	40400	
D	44800		D	45000		H	45200		G	41000	
E	44800		E	45200		I	45200		12 F	40200	
H	44800		H	45400		J	45200	36"	G	40500	30 3/8"
I	45500		I	45200					14 A	12000	6 13/16"
J	44700		J	45600					F	12000	
K	44800		K	45600					G	12000	
L	44800	36"	L	45000	36"				L	12000	6 13/16"

CONCRETE AND CURING INFORMATION

D.O.T. MIX NUMBER: 3580030103

MATERIALS		SCALE WEIGHTS	% MOIS.
CEMENT (lbs.)	TYPE: III	27960	
FLYASH (lbs.)			
SAND (lbs.)		35460	
STONE (lbs.)	SIZE: 67	66020	
WATER (gals.)		98	
AEA (ozs.)		6	
HRWR (ozs.)		178	
OTHER plasticizer		960	

NAME OF PERSONS PERFORMING TEST

NO.
STATION
TIME
SLUMP
% AIR
PLACEMENT TEMP.

CONCRETE CYLINDERS

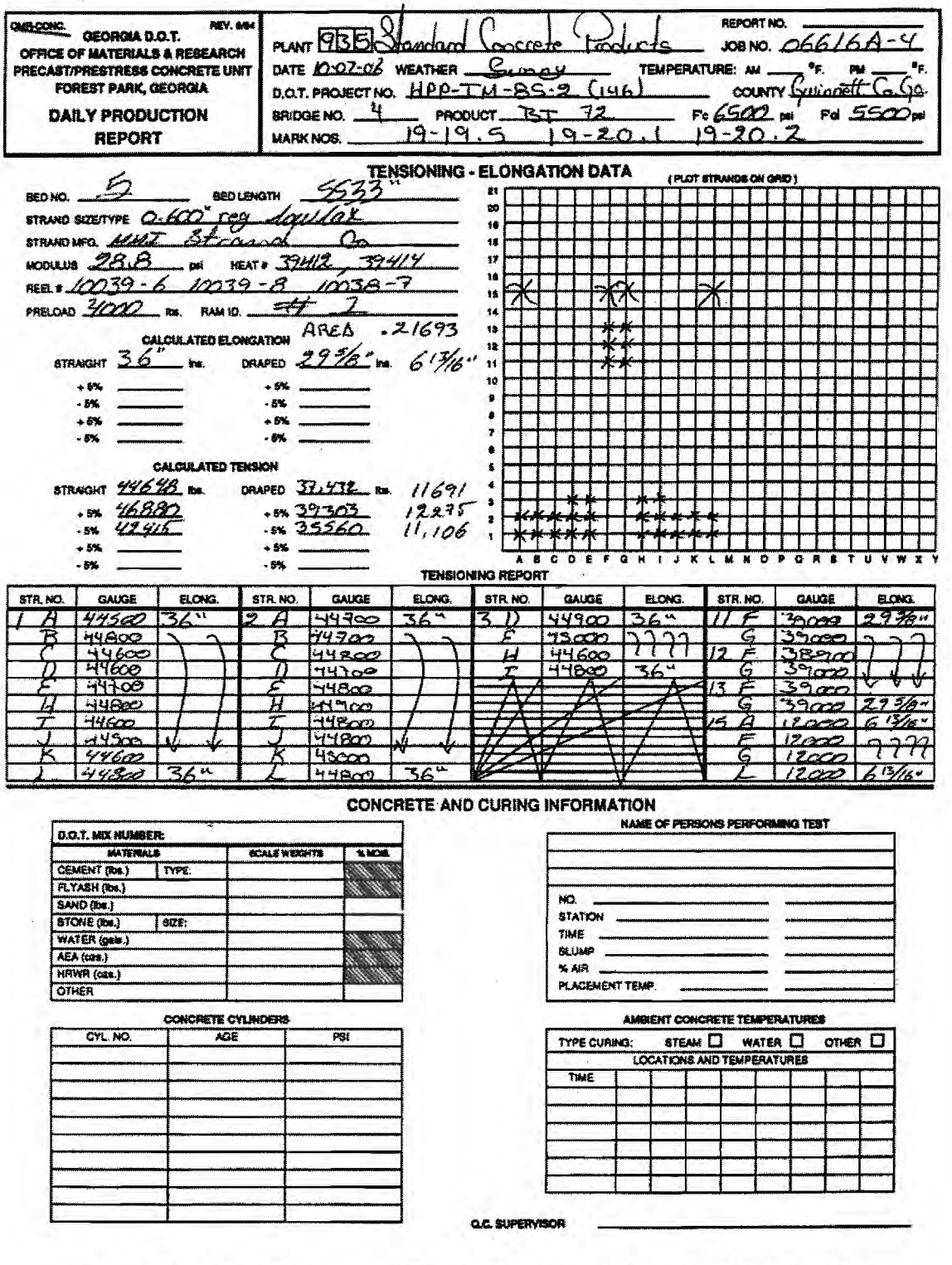
CYL. NO.	AGE	PSI

AMBIENT CONCRETE TEMPERATURES

TYPE CURING: STEAM ☑ WATER ☐ OTHER ☐
LOCATIONS AND TEMPERATURES
TIME

Q.C. SUPERVISOR

Figure D.3 Strand tensioning data field sheets v.ax1, wax2, and none1



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DAILY PRODUCTION REPORT

PLANT 935 Standard Concrete Products — REPORT NO. — JOB NO. 06616A-4
DATE 10-02-06 WEATHER Sunny — TEMPERATURE: AM °F. PM °F.
D.O.T. PROJECT NO. HPP-TM-BS-2 (146) — COUNTY Gwinnett Co. Ga.
BRIDGE NO. 4 — PRODUCT BT 72 — F'c 6500 psi — F'ci 5500 psi
MARK NOS. 19-19.5 19-20.1 19-20.2

TENSIONING - ELONGATION DATA

BED NO. 5 — BED LENGTH 455'3"
STRAND SIZE/TYPE 0.600" reg Special
STRAND MFG. MMT Strand Co
MODULUS 28.8 psi — HEAT # 39412, 39414
REEL # 10039-6 10039-8 10038-7
PRELOAD 3000 lbs. — RAM ID. #7 2 AREA .21693

CALCULATED ELONGATION

	STRAIGHT	DRAPED	
	36" ins.	29 5/8" ins.	6 13/16"
+ 5%			
- 5%			
+ 5%			
- 5%			

CALCULATED TENSION

	STRAIGHT	DRAPED	
	44648 lbs.	37,432 lbs.	11691
+ 5%	46880	39303	12275
- 5%	42416	35560	11,106
+ 5%			
- 5%			

(PLOT STRANDS ON GRID)

TENSIONING REPORT

STR. NO.	GAUGE	ELONG.	STR. NO.	GAUGE	ELONG.	STR. NO.	GAUGE	ELONG.	STR. NO.	GAUGE	ELONG.
1 A	44500	36"	2 A	44900	36"	3 D	44900	36"	11 F	39000	29 5/8"
B	44800		B	44700		E	45000		G	39000	
C	44600		C	44800		H	44600		12 F	38900	
D	44600		D	44700		I	44800	36"	G	39000	
E	44700		E	44800					13 F	39000	
H	44800		H	44900					G	39000	29 5/8"
I	44600		I	44800					15 A	12000	6 13/16"
J	44500		J	44800					F	12000	
K	44600		K	45000					G	12000	
L	44800	36"	L	44800	36"				L	12000	6 13/16"

CONCRETE AND CURING INFORMATION

D.O.T. MIX NUMBER:

MATERIALS		SCALE WEIGHTS	% MOIS.
CEMENT (lbs.)	TYPE:		
FLYASH (lbs.)			
SAND (lbs.)			
STONE (lbs.)	SIZE:		
WATER (gals.)			
AEA (ozs.)			
HRWR (ozs.)			
OTHER			

NAME OF PERSONS PERFORMING TEST

NO.
STATION
TIME
SLUMP
% AIR
PLACEMENT TEMP.

CONCRETE CYLINDERS

CYL. NO.	AGE	PSI

AMBIENT CONCRETE TEMPERATURES

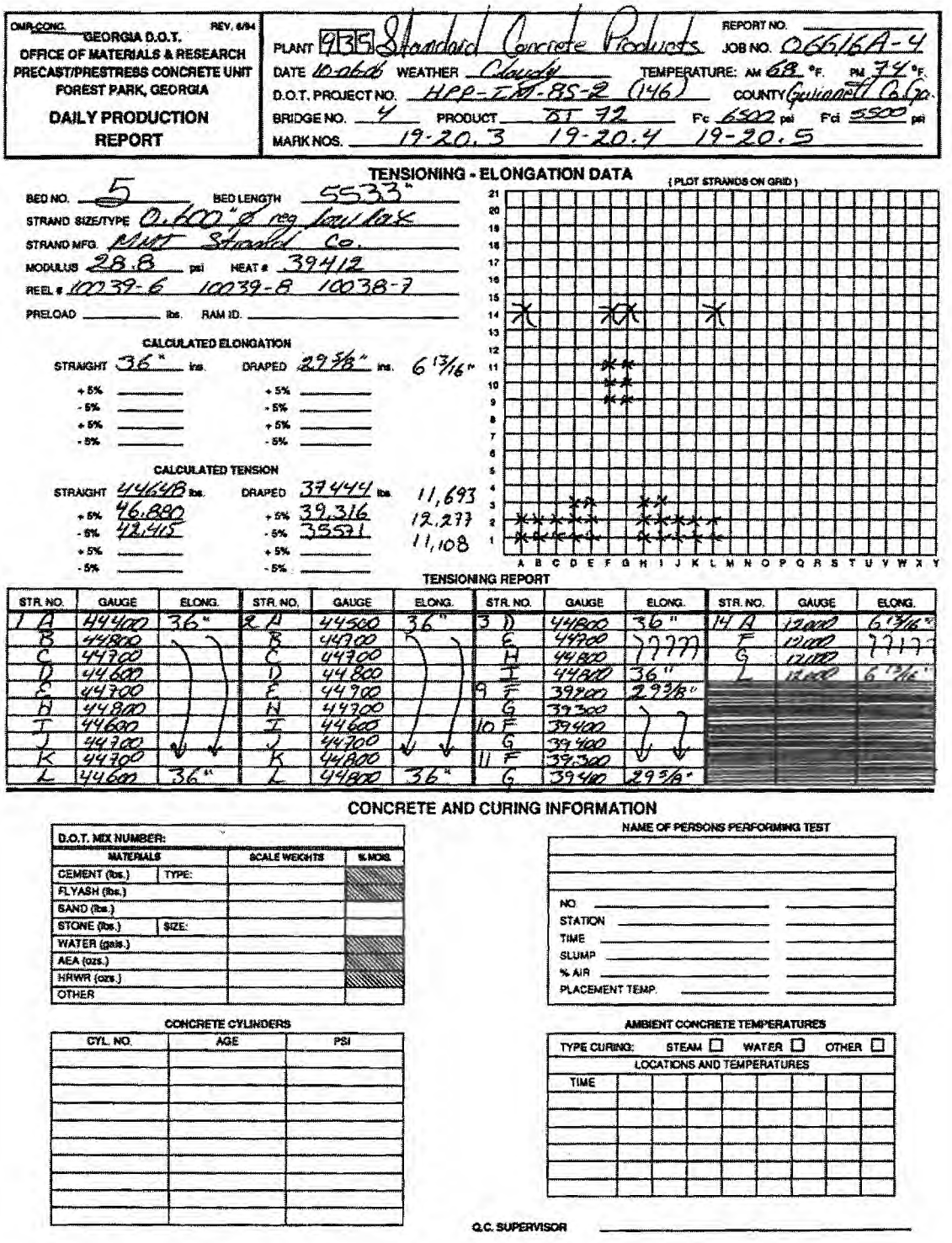
TYPE CURING: STEAM ☐ WATER ☐ OTHER ☐

LOCATIONS AND TEMPERATURES

TIME								

Q.C. SUPERVISOR

Figure D.4 Strand tensioning data field sheets angle1, none2, and plate1



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DAILY PRODUCTION REPORT

PLANT 935 Standard Concrete Products — REPORT NO. — JOB NO. 066164-4
DATE 10-26-06 — WEATHER Cloudy — TEMPERATURE: AM 68 °F. PM 74 °F.
D.O.T. PROJECT NO. HPP-EM-85-2 (146) — COUNTY Gwinnett Co. Ga.
BRIDGE NO. 4 — PRODUCT BT 72 — F'c 6500 psi — F'ci 5500 psi
MARK NOS. 19-20.3 19-20.4 19-20.5

TENSIONING - ELONGATION DATA (PLOT STRANDS ON GRID)

BED NO. 5 — BED LENGTH 553'
STRAND SIZE/TYPE 0.600" ϕ reg low lax
STRAND MFG. Mid State Steel Co.
MODULUS 28.8 psi — HEAT # 39412
REEL # 10039-6 10039-8 10038-7
PRELOAD ____ lbs. — RAM ID. ____

CALCULATED ELONGATION

	STRAIGHT	DRAPED	
	36" ins.	29 3/8" ins.	6 13/16"
+ 5%	____	+ 5% ____	
- 5%	____	- 5% ____	
+ 5%	____	+ 5% ____	
- 5%	____	- 5% ____	

CALCULATED TENSION

	STRAIGHT	DRAPED	
	44648 lbs.	37444 lbs.	11,693
+ 5%	46,880	+ 5% 39,316	12,277
- 5%	42,415	- 5% 35521	11,108
+ 5%	____	+ 5% ____	
- 5%	____	- 5% ____	

TENSIONING REPORT

STR. NO.	GAUGE	ELONG.	STR. NO.	GAUGE	ELONG.	STR. NO.	GAUGE	ELONG.	STR. NO.	GAUGE	ELONG.
1 A	44400	36"	2 A	44500	36"	3 D	44800	36"	14 A	12000	6 13/16"
B	44800		B	44700		E	44900		F	12000	
C	44900		C	44900		H	44800		G	12000	
D	44600		D	44800		I	44800	36"	L	12000	6 13/16"
E	44700		E	44900		9 F	39900	29 3/8"			
H	44800		H	44700		G	39300				
I	44600		I	44600		10 F	39400				
J	44700		J	44700		G	39400				
K	44900		K	44800		11 F	39300				
L	44600	36"	L	44800	36"	G	39400	29 3/8"			

CONCRETE AND CURING INFORMATION

D.O.T. MIX NUMBER:

MATERIALS		SCALE WEIGHTS	% MOIS.
CEMENT (lbs.)	TYPE:		
FLYASH (lbs.)			
SAND (lbs.)			
STONE (lbs.)	SIZE:		
WATER (gals.)			
AEA (ozs.)			
HRWR (ozs.)			
OTHER			

NAME OF PERSONS PERFORMING TEST

NO.
STATION
TIME
SLUMP
% AIR
PLACEMENT TEMP.

CONCRETE CYLINDERS

CYL. NO.	AGE	PSI

AMBIENT CONCRETE TEMPERATURES

TYPE CURING: STEAM ☐ WATER ☐ OTHER ☐

LOCATIONS AND TEMPERATURES

TIME									

Q.C. SUPERVISOR ____

Figure D.5 Strand tensioning data field sheets plate2, pad4, and angle2

APPENDIX E

FIELD SHEETS FOR CONCRETE PROPERTIES OF GIRDERS

This Appendix contains field data sheets for concrete properties of the 12 girders tested for the field test experiments at the time the prestressing strands were cut.

QUALITY CONTROL DEPARTMENT

COUNTY: Gwinnett Co. PROJ. NO.: HPP-IM-85-2(146) JOB: 06616A-4

lab test

CASTING DATE: 09-27-06

TEST NO.	1	2	3	4	5
SLUMP - INCHES	7 1/2	7"	7 1/2		
AIR CONTENT PERCENT	2.8%	1.8%	2.3		
AMBIENCE TEMP. F°	56°	69°	64°		
CONCRETE TEMP. F°	79°	82.9°	89.9°		
TIME OF TEST	8:44am	10:01	11:30		

FAR: _____ NEAR: _____ 28 DAY STRENGTH 7,500 RELEASE (PSI) / MPA: 6,000

DATE	LOAD / FAR	PSI / MPA	LOAD / NEAR	PSI / MPA
9/27/06	[illegible]	[illegible]	96,147	7651
9/28/06	91,736	7,300		

Q.C. LAB beam set up JACKSON PKWY.

1825101010101050101041010103101015010101010140101015010101031010101405101010101010960921O

BED NO. 6

Q.C. LAB JACKSON PKWY

17-13.1 17-14.1 17-15.1

Q.C. LAB JACKSON PKWY

COMMENTS: Pour start = 8:50am End Pour 11:45

STANDARD CONCRETE PRODUCTS - ATLANTA PLANT SAMPLED BY:

Figure E.1 Concrete property field sheets pad1, pad2, and pad3

QUALITY CONTROL DEPARTMENT

COUNTY: GWINNETT GA PROJ. NO.: HPP-IM-85-2(146) JOB: 006164-1

Lab test

SUPPLIERS DATE MADE: 09-30-06

CEMENT	
FINE AGGREGATE	
COARSE AGGREGATE	
FLY ASH	
MICRO SILICA	
WATER	
WATER REDUCER	
HIGH RANGE WATER REDUCER	
AIR ENTRAINMENT	

TEST NO.	1	2	3	4	5
SLUMP - INCHES	6 1/2"	8"	8"		
AIR CONTENT PERCENT	3.5%	~~3.5%~~ 2.5%	2.5%		
AMBIENCE TEMP. F°	67°	81°	70°		
CONCRETE TEMP. F°	79°	~~81°~~ 77°	82.9°		
TIME OF TEST	1:30 PM	2:20 PM	1:00 PM		

FAR: 10 NEAR: 10 BED NO.: 5 RELEASE PSI / ~~MPA~~: 6,000

SPECIMEN ID	AGE DAYS	DATE	TOTAL LOAD	PSI / ~~MPA~~	CYL. SIZE
FAR	2	10-02-06	103243	8,216	
NEAR	2	10-02-06	89,347	7,110	
FAR					
NEAR					

Q.C. LAB BEAM LOCATION JACKSON PKWY.

17-16.1 17-10.5 17-11.5

COMMENTS:

STANDARD CONCRETE PRODUCTS - ATLANTA PLANT SAMPLED BY: RA

Figure E.2 Concrete property field sheets wax1, wax2, and none1

QUALITY CONTROL DEPARTMENT

COUNTY: Gwinnett Co. PROJ. NO.: JOB: 06616A-4

Lab test

SUPPLIERS DATE MADE: 10-03-06

CEMENT	752 Ga.
FINE AGGREGATE	
COARSE AGGREGATE	
FLY ASH	
MICRO SILICA	
WATER	
WATER REDUCER	
HIGH RANGE WATER REDUCER	
AIR ENTRAINMENT	

TEST NO.	1	2	3	4	5
SLUMP - INCHES	7"	7½"	7¼"		
AIR CONTENT PERCENT	2.3	2.0	2.9%		
AMBIENCE TEMP. F°	80°	80°	75°		
CONCRETE TEMP. F°	89°	83°	74.7°		
TIME OF TEST	4:30	5:20	6:45 PM		

FAR: 10 NEAR: 10 BED NO.: ~~Bed 5~~ RELEASE PSI / MPA: 5500

SPECIMEN ID	AGE DAYS	DATE	TOTAL LOAD	PSI / MPA	CYL. SIZE
FAR	1	10-04-06	74.389	5,919	
NEAR	1	10-04-06	74.206	5,805	
FAR					
NEAR					

O.C. LAB BEAM LOCATION JACKSON PKWY.

19-19.5 19-20.1 19-20.2

COMMENTS: Pour start 4:30

STANDARD CONCRETE PRODUCTS - ATLANTA PLANT SAMPLED BY: Andrew Gavin

Figure E.3 Concrete property field sheets angle1, none2, and plate1

QUALITY CONTROL DEPARTMENT

COUNTY: GWINNET PROJ. NO.: JOB: 06616A-4

Lab test

CASTING DATE: 10-6-06

TEST NO.	1	2	3	4	5
SLUMP - INCHES	6"	6"	7"		
AIR CONTENT PERCENT	4.5%	2.8%	2.6%		
AMBIENCE TEMP. F°	72°	84°	65°		
CONCRETE TEMP. F°	86°	72°	87.8°		
TIME OF TEST	5:15pm	6:23	7:00		

FAR: 8 NEAR: 28 DAY STRENGTH 6,500 Psi RELEASE (PSI) / ~~MPA~~: 5,500

DATE	LOAD / FAR	PSI / MPA	LOAD / NEAR	(PSI) / MPA
10-9-06	92471	7400	100402	7957

Q.C. LAB beam set up JACKSON PKWY.

1525101010101050101041010103101015010101014010101501010103 10101014051010101010101066692 10

Q.C. LAB BED NO. 5 JACKSON PKWY

19-20.3	19-20.4	19-20.5

Q.C. LAB JACKSON PKWY

COMMENTS: Start Pour 5:20
Finish Pour 7:30

STANDARD CONCRETE PRODUCTS - ATLANTA PLANT SAMPLED BY: SERITA & SA

Figure E.4 Concrete property field sheets plate2, pad4, and angle2

APPENDIX F

STRAIN AND GIRDER SLIDE DATA

This Appendix contains strain for the 12 girders tested for the field test experiments using values from the field data presented in Appendix B.

Measurements for strain and girder slide were taken on both the north and south sides of the girders, on both the east and west ends. All strain values were compression strain and were designated a "-" value. Girder slide was the measured movement exhibited by the ends of the girders. Movement in the west direction was given a "+" value and movement in the east direction was given a "-" value.

The initial length (L_o) was the center to center spacing of the epoxy bonded steel stubs. This distance was assumed to be 10 in. for the calculation of strain values given in tables in Chapter VI. Though the actual distance varied by $\pm$ the initial DEMEC gauge reading (L_o DEMEC), the difference wasn't significant enough to vary strain values. L_o DEMEC was the value on the DEMEC strain gauge before the prestressing strands were cut. $L_{1\ Bed}$ was the value on the DEMEC strain gauge after the prestressing strands were cut while the girders were on the casting bed. $L_{1\ Move}$ was the value on the DEMEC strain gauge after the girders were moved off the casting bed.

Table F.1 Strain and girder slide pad1, pad2, and pad3

Ref. Name	Beam	Side	End	Lo (in)	Lo (DEMEC)	$L_{1\ Bed}$	$L_{1\ Move}$	Girder Slide (in)
Pad1	1	North	East	10	0.0302	0.0326	0.0367	1 17/32
		North	West	10	-0.0064	-0.0031	0.0008	0
		South	East	10	0.0178	0.0220	0.0269	1 17/32
		South	West	10	-0.0118	-0.0081	-0.0068	0
Pad2	2	North	East	10	-0.0292	-0.0206	-0.0168	29/64
		North	West	10	-0.0061	-0.0022	-0.0009	-1 3/4
		South	East	10	-0.0136	-0.0065	-0.0035	29/64
		South	West	10	-0.0213	-0.0161	-0.0120	-1 3/4
Pad3	3	North	East	10	-0.0180	-0.0157	-0.0130	1 1/32
		North	West	10	-0.0193	-0.0178	-0.0156	- 11/64
		South	East	10	-0.0165	-0.0133	-0.0116	1 1/32
		South	West	10	-0.0036	0.0009	0.0033	- 11/64

Table F.2 Strain and girder slide wax1, wax2, and none1

Ref. Name	Beam	Side	End	Lo (in)	Lo (DEMEC)	$L_{1\ Bed}$	$L_{1\ Move}$	Girder Slide (in)
Wax1	1	North	East	10	-0.0111	-0.0078	-0.0061	3/4
		North	West	10	0.0001	0.0054	0.0066	-2 1/16
		South	East	10	-0.0066	-0.0040	-0.0022	3/4
		South	West	10	-0.0026	0.0003	0.0015	-2 1/16
Wax2	2	North	East	10	0.0117	0.0149	0.0161	2 1/32
		North	West	10	-0.0117	-0.0043	-0.0035	3 19/32
		South	East	10	-0.0112	-0.0080	-0.0062	2 1/32
		South	West	10	-0.0326	-0.0255	-0.0233	3 19/32
None1	3	North	East	10	-0.0028	0.0018	0.0031	11/16
		North	West	10	0.0075	0.0099	0.0111	- 19/32
		South	East	10	-0.0165	-0.0131	-0.0112	11/16
		South	West	10	-0.0227	-0.0204	-0.0093	- 19/32

Table F.3 Strain and girder slide angle1, none2, and plate1

Ref. Name	Beam	Side	End	Lo (in)	Lo (DEMEC)	$L_{1\ Bed}$	$L_{1\ Move}$	Girder Slide (in)
Angle1	1	North	East	10	-0.0080	-0.0032	-0.0028	9/16
		North	West	10	-0.0187	-0.0119	-0.0108	- 27/32
		South	East	10	-0.0010	0.0032	0.0035	9/16
		South	West	10	-0.0155	-0.0084	-0.0078	- 27/32
None2	2	North	East	10	-0.0165	-0.0121	-0.0088	11/16
		North	West	10	-0.0122	-0.0068	-0.0018	- 1/2
		South	East	10	-0.0065	-0.0021	0.0008	11/16
		South	West	10	-0.0060	-0.0022	0.0010	- 1/2
Plate1	3	North	East	10	-0.0082	-0.0047	-0.0039	25/32
		North	West	10	-0.0070	-0.0028	-0.0020	- 25/32
		South	East	10	-0.0067	-0.0019	-0.0011	25/32
		South	West	10	-0.0057	0.0004	0.0012	- 25/32

Table F.4 Strain and girder slide plate2, pad4, and angle2

Ref. Name	Beam	Side	End	Lo (in)	Lo (DEMEC)	$L_{1\ Bed}$	$L_{1\ Move}$	Girder Slide (in)
Plate2	1	North	East	10	0.0262	0.0318	0.0327	-1 15/32
		North	West	10	0.0185	0.0241	0.0259	-2 7/8
		South	East	10	0.0280	0.0345	0.0362	-1 15/32
		South	West	10	0.0173	0.0227	0.0240	-2 7/8
Pad4	2	North	East	10	0.0242	0.0280	0.0322	2 9/32
		North	West	10	0.0123	0.0172	0.0210	1 1/16
		South	East	10	0.0217	0.0274	0.0318	2 9/32
		South	West	10	0.0094	0.0160	0.0202	1 1/16
Angle2	3	North	East	10	0.0151	0.0203	0.0216	29/32
		North	West	10	0.0189	0.0255	0.0263	- 1/2
		South	East	10	0.0243	0.0326	0.0340	29/32
		South	West	10	0.0276	0.0330	0.0341	- 1/2

APPENDIX G

CAMBER AND GIRDER SWEEP CALCULATION

This Appendix contains camber and girder sweep values for the 12 girders tested for the field test experiments using values from the field data presented in Appendix C.

The horizontal angles in Appendix C were presented in degrees, minutes, and seconds. That was converted into a decimal degree by dividing the second values by 60, adding that decimal to the minute value, dividing that number by 60, and adding that decimal to the degree value.

The camber of each girder was found after the strands were cut and after the girders were moved off of the casting bed. Camber after the prestressing strands were cut (camber on the bed) was calculated by taking the change in elevation (Z) after the prestressing strands were cut less the elevation before the prestressing strands were cut. Camber after the girders were moved off of the casting bed was found by using the elevation of the end points. If the girders were perfectly flat, the elevation of the midpoint would be the average value of the difference in elevation of the two ends. For instance, if the elevation of the east end was eight feet and the elevation of the west end was six feet, the elevation of the midpoint would be seven feet if the girder had no camber. Knowing the elevation of the midpoint if the girder had no camber, that elevation was subtracted from the elevation found from the total station, which was the camber of the girder after it was moved off of the casting bed.

The girder sweep was calculated by using the Law of Cosines. Sides A, B, and C can be found for any arbitrary triangle using the equation for the law of cosines[8]:

$$A^2 = B^2 + C^2 - 2BC*\cos(\theta_A)$$

Where:

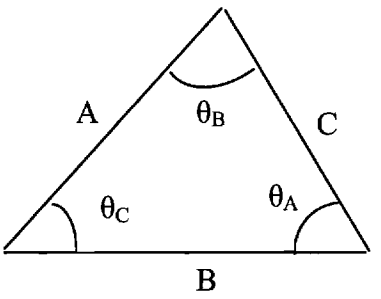

Figure G.1 Labeled triangle for explaining law of cosines

Using the initial total station readings as a reference, the girder sweep after the prestressing strands were cut was found. For example, the girder sweep on the casting bed was found by using the HD to the midpoint before and after the prestressing strands were cut. The difference in HR to the midpoint before and after the prestressing strands were cut was θ_A for the law of cosines equation. With that information two sides and the angle of the unknown side of the triangle are known. The girder sweep is the unknown side of the triangle as shown in Figure G.2. The girder sweep was found by taking the square root of the law of cosines equation using the aforementioned values.

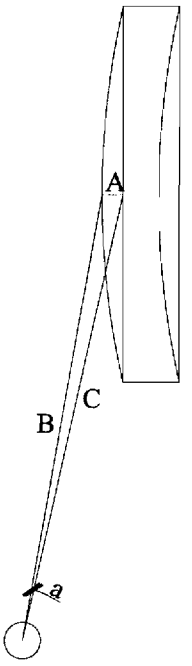

Figure G.2 Girder sweep after the strands were cut

The girder sweep after the girders were moved off of the casting bed was calculated differently because there was no initial reference point to use. A triangle was formed using imaginary lines from the ends of the girder to the midpoint shown in Figure G.3

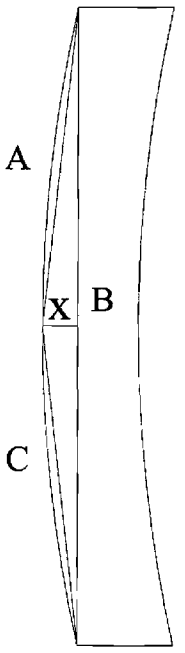

Figure G.3 Girder sweep after the girder was moved off the casting bed

The Law of Cosines was found for each leg of the imaginary triangle shown in Figure G.3 using the horizontal distances found by the Total Station and the corresponding angle difference from one point on the girder to the other. A used data from one end of the girder and the midpoint, C used data from the other end of the girder and the midpoint, and B used data from the two ends of the girder. The small angles of the girder were found by using the Law of Cosines and rearranging the equation to solve for the angle. The average of the small angles of the triangle was used since the survey tack placed at the midpoint of the girder wasn't at the exact midpoint, averaging the two angles better represented the midpoint rotation angle. Geometry was used knowing the rotation angle at the end and the length of the hypotenuse of the imaginary triangle to find the girder sweep, shown as X in Figure G.3.

Values for girder sweep after the girders were moved off of the casting bed were typically larger than the values for girder sweep while the girders were on the casting bed just after cutting the prestressing strands. Some values did not show this relationship. This error was assumed to be a result of the slight inaccuracy of acquiring data using the Total Station.

Data for plate2 wasn't able to be collected due to complications that arose at Standard Concrete Products at the time the girder was moved off the casting bed.

Table G.1 Total station readings pad1, pad2, and pad3 before strands cut, on the bed

Ref. Name	Beam	Point	HR (°, ', ")			HD (ft)	Z (ft)
Pad1	17-13.1	East End	15	56	25	580.725	14.410
		Mid Pt.	15	50	15	521.895	13.925
		West End	15	41	40	459.340	13.405
Pad2	17-14.1	East End	15	39	25	448.635	13.315
		Mid Pt.	15	28	30	388.735	12.805
		West End	15	12	30	327.350	12.335
Pad3	17-15.1	East End	15	8	0	318.395	12.260
		Mid Pt.	14	49	35	266.965	11.870
		West End	14	8	50	197.325	11.285

Table G.2 Total station readings pad1, pad2, and pad3 after strands cut, on the bed

Ref. Name	Beam	Point	HR (°, ', ")			HD (ft)	Z (ft)
Pad1	17-13.1	East End	15	57	40	580.605	14.390
		Mid Pt.	15	50	30	521.875	14.105
		West End	15	42	0	459.315	13.410
Pad2	17-14.1	East End	15	40	10	448.650	13.330
		Mid Pt.	15	29	0	388.840	13.000
		West End	15	12	55	327.450	12.335
Pad3	17-15.1	East End	15	8	30	318.335	12.250
		Mid Pt.	14	50	25	266.905	12.040
		West End	14	8	55	197.270	11.270

Table G.3 Total station readings pad1, pad2, and pad3 girder moved off bed

Ref. Name	Beam	Point	HR (°, ', ")			HD (ft)	Z (ft)
Pad1	17-13.1	East End	30	46	35	141.210	8.070
		Mid Pt.	28	19	20	199.535	7.630
		West End	26	53	30	261.855	6.635
Pad2	17-14.1	East End	32	17	20	140.630	7.800
		Mid Pt.	29	22	25	200.340	7.425
		West End	27	43	55	261.450	6.510
Pad3	17-15.1	East End	27	42	0	140.325	7.660
		Mid Pt.	26	8	45	199.690	7.600
		West End	25	10	15	261.280	7.015

Table G.4 Total station readings wax1, wax2, and none1 before strands cut, on the bed

Ref. Name	Beam	Point	HR (°, ', ")			HD (ft)	Z (ft)
Wax1	17-16.1	East End	38	20	5	44.815	8.620
		Mid Pt.	24	45	55	104.230	8.100
		West End	21	2	55	165.800	7.605
Wax2	17-10.5	East End	19	44	55	183.745	9.740
		Mid Pt.	18	45	0	245.305	10.275
		West End	18	9	50	306.840	10.735
None1	17-11.5	East End	18	5	45	318.290	10.835
		Mid Pt.	17	45	30	378.605	11.440
		West End	17	28	40	441.490	11.925

Table G.5 Total station readings wax1, wax2, and none1 after strands cut, on the bed

Ref. Name	Beam	Point	HR (°, ', ")			HD (ft)	Z (ft)
Wax1	17-16.1	East End	38	19	30	44.830	8.615
		Mid Pt.	24	45	30	104.150	8.285
		West End	21	3	5	165.780	7.595
Wax2	17-10.5	East End	19	44	40	183.720	9.730
		Mid Pt.	18	44	45	245.235	10.455
		West End	18	9	55	306.805	10.720
None1	17-11.5	East End	18	5	30	318.250	10.855
		Mid Pt.	17	45	0	378.550	11.605
		West End	17	28	55	441.590	11.910

Table G.6 Total station readings wax1, wax2, and none1 girders moved off bed

Ref. Name	Beam	Point	HR (°, ', ")			HD (ft)	Z (ft)
Wax1	17-16.1	East End	41	38	5	142.835	7.850
		Mid Pt.	39	47	40	202.230	6.810
		West End	38	42	20	263.925	5.225
Wax2	17-10.5	East End	32	5	30	138.750	8.415
		Mid Pt.	33	15	15	200.305	7.000
		West End	33	54	10	261.990	5.000
None1	17-11.5	East End	33	49	20	137.955	8.365
		Mid Pt.	34	23	10	198.225	6.980
		West End	34	40	15	261.290	5.050

Table G.7 Total station readings angle1, none2, and plate1 before strands cut, on the bed

Ref. Name	Beam	Point	HR (°, ', ")			HD (ft)	Z (ft)
Angle1	19-19.5	East End	36	8	5	89.695	8.780
		Mid Pt.	26	52	0	148.280	8.245
		West End	22	55	5	208.620	7.860
None2	19-20.1	East End	22	22	5	220.780	7.725
		Mid Pt.	20	24	55	281.935	7.200
		West End	19	7	50	342.740	6.790
Plate1	19-20.2	East End	18	56	25	355.605	6.625
		Mid Pt.	18	7	55	415.530	6.100
		West End	17	29	45	478.575	5.700

Table G.8 Total station readings angle1, none2, and plate1 after strands cut, on the bed

Ref. Name	Beam	Point	HR (°, ', ")			HD (ft)	Z (ft)
Angle1	19-19.5	East End	36	8	55	89.650	8.815
		Mid Pt.	26	52	20	148.225	8.485
		West End	22	55	0	208.630	7.845
None2	19-20.1	East End	22	22	25	220.705	7.725
		Mid Pt.	20	24	10	281.845	7.420
		West End	19	7	35	342.790	6.765
Plate1	19-20.2	East End	18	56	0	355.685	6.600
		Mid Pt.	18	7	45	415.440	6.340
		West End	17	29	15	478.205	5.715

Table G.9 Total station readings angle1, none2, and plate1 girders moved off bed

Ref. Name	Beam	Point	HR (°, ', ")			HD (ft)	Z (ft)
Angle1	19-19.5	East End	16	1	40	359.150	6.080
		Mid Pt.	16	5	40	419.130	5.770
		West End	16	10	10	482.145	4.945
None2	19-20.1	East End	15	33	25	223.200	7.440
		Mid Pt.	15	37	20	284.935	6.995
		West End	15	43	40	346.315	6.030
Plate1	19-20.2	East End	26	14	30	89.750	9.105
		Mid Pt.	22	30	25	150.670	8.690
		West End	20	50	35	212.110	7.745

Table G.10 Total station readings plate2, pad4, and angle2 before strands cut, on the bed

Ref. Name	Beam	Point	HR (°, ', ")			HD (ft)	Z (ft)
Plate2	19-20.3	East End	36	9	55	89.645	7.450
		Mid Pt.	26	51	0	149.020	6.925
		West End	22	54	40	208.905	6.465
Pad4	19-20.4	East End	22	22	25	220.980	6.320
		Mid Pt.	20	23	40	282.250	5.805
		West End	19	6	5	343.240	5.375
Angle2	19-20.5	East End	18	56	20	355.845	5.240
		Mid Pt.	18	5	5	417.370	4.720
		West End	17	29	0	478.520	4.265

Table G.11 Total station readings plate2, pad4, and angle2 after strands cut, on the bed

Ref. Name	Beam	Point	HR (°, ', ")			HD (ft)	Z (ft)
Plate2	19-20.3	East End	36	9	35	89.765	7.475
		Mid Pt.	26	51	30	148.965	7.165
		West End	22	54	35	208.780	6.480
Pad4	19-20.4	East End	22	22	40	221.215	6.330
		Mid Pt.	20	23	20	282.350	6.025
		West End	19	6	35	343.395	5.345
Angle2	19-20.5	East End	18	56	30	355.890	5.260
		Mid Pt.	18	5	10	417.400	4.955
		West End	17	29	20	478.505	4.260

Table G.12 Total station readings plate2, pad4, and angle2 girders moved off bed

Ref. Name	Beam	Point	HR (°, ', ")			HD (ft)	Z (ft)
Plate2	19-20.3	East End	-	-	-	-	-
		Mid Pt.	-	-	-	-	-
		West End	-	-	-	-	-
Pad4	19-20.4	East End	29	16	40	83.375	12.230
		Mid Pt.	29	10	15	144.830	12.350
		West End	29	5	10	206.560	11.940
Angle2	19-20.5	East End	28	28	30	71.160	9.680
		Mid Pt.	28	44	35	132.475	9.880
		West End	28	47	35	194.280	9.585

Table G.13 Camber and sweep for pad1, pad2, and pad3 after strands cut, on the bed

Ref. Name	Beam	Point	HR (°)	HD (ft)	Z (ft)	Camber (in)	Sweep (in)
Pad1	17-13.1	East End	15.96	580.605	14.390	-	-
		Mid Pt.	15.84	521.875	14.105	2.16	0.51
		West End	15.70	459.315	13.410	-	-
Pad2	17-14.1	East End	15.67	448.650	13.330	-	-
		Mid Pt.	15.48	388.840	13.000	2.34	1.43
		West End	15.22	327.450	12.335	-	-
Pad3	17-15.1	East End	15.14	318.335	12.250	-	-
		Mid Pt.	14.84	266.905	12.040	2.04	1.06
		West End	14.15	197.270	11.270	-	-

Table G.14 Camber and sweep for pad1, pad2, and pad3 girders moved off bed

Ref. Name	Beam	Point	HR (°)	HD (ft)	Z (ft)	Camber (in)	Sweep (in)
Pad1	17-13.1	East End	30.78	141.210	8.070	-	-
		Mid Pt.	28.32	199.535	7.630	3.33	0.59
		West End	26.89	261.855	6.635	-	-
Pad2	17-14.1	East End	32.29	140.630	7.800	-	-
		Mid Pt.	29.37	200.340	7.425	3.24	1.22
		West End	27.73	261.450	6.510	-	-
Pad3	17-15.1	East End	27.70	140.325	7.660	-	-
		Mid Pt.	26.15	199.690	7.600	3.15	3.01
		West End	25.17	261.280	7.015	-	-

Table G.15 Camber and sweep for wax1, wax2, and none1 after strands cut, on the bed

Ref. Name	Beam	Point	HR (°)	HD (ft)	Z (ft)	Camber (in)	Sweep (in)
Wax1	17-16.1	East End	38.33	44.830	8.615	-	-
		Mid Pt.	24.76	104.150	8.285	2.22	0.97
		West End	21.05	165.780	7.595	-	-
Wax2	17-10.5	East End	19.74	183.720	9.730	-	-
		Mid Pt.	18.75	245.235	10.455	2.16	0.87
		West End	18.17	306.805	10.720	-	-
None1	17-11.5	East End	18.09	318.250	10.855	-	-
		Mid Pt.	17.75	378.550	11.605	1.98	0.93
		West End	17.48	441.590	11.910	-	-

Table G.16 Camber and sweep for wax1, wax2, and none1 girders moved off bed

Ref. Name	Beam	Point	HR (°)	HD (ft)	Z (ft)	Camber (in)	Sweep (in)
Wax1	17-16.1	East End	41.63	142.835	7.850	-	-
		Mid Pt.	39.79	202.230	6.810	3.27	1.56
		West End	38.71	263.925	5.225	-	-
Wax2	17-10.5	East End	32.09	138.750	8.415	-	-
		Mid Pt.	33.25	200.305	7.000	3.51	0.88
		West End	33.90	261.990	5.000	-	-
None1	17-11.5	East End	33.82	137.955	8.365	-	-
		Mid Pt.	34.39	198.225	6.980	3.27	0.73
		West End	34.67	261.290	5.050	-	-

Table G.17 Camber and sweep for angle1, none2, and plate1 after strands cut, on the bed

Ref. Name	Beam	Point	HR (°)	HD (ft)	Z (ft)	Camber (in)	Sweep (in)
Angle1	19-19.5	East End	36.15	89.650	8.815	-	-
		Mid Pt.	26.87	148.225	8.485	2.88	0.68
		West End	22.92	208.630	7.845	-	-
None2	19-20.1	East End	22.37	220.705	7.725	-	-
		Mid Pt.	20.40	281.845	7.420	2.64	1.31
		West End	19.13	342.790	6.765	-	-
Plate1	19-20.2	East End	18.93	355.685	6.600	-	-
		Mid Pt.	18.13	415.440	6.340	2.88	1.11
		West End	17.49	478.205	5.715	-	-

Table G.18 Camber and sweep for angle1, none2, and plate1 girders moved off bed

Ref. Name	Beam	Point	HR (°)	HD (ft)	Z (ft)	Camber (in)	Sweep (in)
Angle1	19-19.5	East End	16.03	359.150	6.080	-	-
		Mid Pt.	16.09	419.130	5.770	3.09	1.15
		West End	16.17	482.145	4.945	-	-
None2	19-20.1	East End	15.56	223.200	7.440	-	-
		Mid Pt.	15.62	284.935	6.995	3.12	2.31
		West End	15.73	346.315	6.030	-	-
Plate1	19-20.2	East End	26.24	89.750	9.105	-	-
		Mid Pt.	22.51	150.670	8.690	3.18	1.73
		West End	20.84	212.110	7.745	-	-

Table G.19 Camber and sweep for plate2, pad4, and angle2 after strands cut, on the bed

Ref. Name	Beam	Point	HR (°)	HD (ft)	Z (ft)	Camber (in)	Sweep (in)
Plate2	19-20.3	East End	36.16	89.765	7.475	-	-
		Mid Pt.	26.86	148.965	7.165	2.88	0.71
		West End	22.91	208.780	6.480	-	-
Pad4	19-20.4	East End	22.38	221.215	6.330	-	-
		Mid Pt.	20.39	282.350	6.025	2.64	1.24
		West End	19.11	343.395	5.345	-	-
Angle2	19-20.5	East End	18.94	355.890	5.260	-	-
		Mid Pt.	18.09	417.400	4.955	2.82	0.38
		West End	17.49	478.505	4.260	-	-

Table G.20 Camber and sweep for plate2, pad4, and angle2 girders moved off bed

Ref. Name	Beam	Point	HR (°)	HD (ft)	Z (ft)	Camber (in)	Sweep (in)
Plate2	19-20.3	East End	-	-	-	-	-
		Mid Pt.	-	-	-	-	-
		West End	-	-	-	-	-
Pad4	19-20.4	East End	29.28	83.375	12.230	-	-
		Mid Pt.	29.17	144.830	12.350	3.18	0.89
		West End	29.09	206.560	11.940	-	-
Angle2	19-20.5	East End	28.48	71.160	9.680	-	-
		Mid Pt.	28.74	132.475	9.880	2.97	1.00
		West End	28.79	194.280	9.585	-	-

APPENDIX H

SUMMATION STRAND FORCES

This Appendix contains Table H.1, calculating of the summation of strand tension forces from field sheets provided in Appendix D. The force calculated in Table H.1 was provided in tables in Chapter VI to qualitatively characterize the performance of the five end conditions. The strand no. outlined in Table H.1 followed the strand orientation presented in Figure D.1. A "-" means that there was no strand in that location for that specific set of girders.

Table H.1 Tension forces for prestressing strands in field test girders

Force per Strand for Beams (kip)				
Strand No.	17-13.1	17-16.1	19-19.5	19-20.3
	17-14.1	17-10.5	19-20.1	19-20.4
	17-15.1	17-11.5	19-20.2	19-20.5
A1	44.4	44.8	44.5	44.4
B1	44.7	45.0	44.8	44.8
C1	44.5	45.0	44.6	44.7
D1	44.6	44.8	44.6	44.6
E1	44.3	44.4	44.7	44.7
H1	44.7	44.8	44.8	44.8
I1	44.6	44.5	44.6	44.6
J1	44.6	44.7	44.5	44.7
K1	44.8	44.8	44.6	44.7
L1	44.8	44.8	44.8	44.6
A2	44.4	44.8	44.7	44.5
B2	44.7	45.2	44.7	44.7
C2	44.7	45.2	44.8	44.7
D2	44.7	45.0	44.7	44.8
E2	44.3	45.2	44.8	44.9
H2	44.5	45.4	44.9	44.7
I2	44.7	45.2	44.8	44.6
J2	44.4	45.6	44.8	44.7
K2	44.2	45.6	45.0	44.8
L2	44.6	45.0	44.8	44.8
C3	44.7	45.0	-	-
D3	44.3	45.0	44.9	44.8
E3	44.5	45.0	45.0	44.7

Table H.1 Tension forces for prestressing strands in field test girders (continued)

Strand No.	Force per Strand for Beams (kip)			
	17-13.1	17-16.1	19-19.5	19-20.3
	17-14.1	17-10.5	19-20.1	19-20.4
	17-15.1	17-11.5	19-20.2	19-20.5
H3	44.6	45.2	44.6	44.8
I3	44.4	45.2	44.8	44.8
J3	44.7	45.2	-	-
F9	-	-	-	39.8
G9	-	-	-	39.3
F10	-	40.2	-	39.4
G10	-	40.0	-	39.4
F11	38.8	40.4	39.0	39.3
G11	38.7	41.0	39.0	39.4
F12	38.6	40.2	38.9	-
G12	38.7	40.5	39.0	-
F13	38.7	-	39.0	-
G13	38.9	-	39.0	-
A14	-	12.0	-	12.0
F14	-	12.0	-	12.0
G14	-	12.0	-	12.0
L14	-	12.0	-	12.0
A15	12.0	-	12.0	-
F15	12.0	-	12.0	-
G15	12.0	-	12.0	-
L15	12.0	-	12.0	-
Total Force =	1438.8	1460.7	1355.7	1357.5

APPENDIX I

MIX DESIGN WEIGHTS

This Appendix contains the total weight of the mix designs for each of the field test girders provided in Chapter VI. The weight was calculated by taking the average batch weight in the mix design used for each girder and multiplying by the volume for that specific girder. The volume was provided by Standard Concrete Products. The average batch weight per cubic yard was found by taking the summation of cement, stone, sand, water, and admixtures in the mix design for each batch mix, dividing by the volume of 3 ½ cubic yards, the constant volume per batch, and dividing by the number of batches used. The conversion of gallons of water to lbs of water was 8.342. The conversion of ounces of admixtures to lbs was 0.0652. The density of admixtures was assumed to be the same as water, 62.4 lbs/ft^3. The mix design field sheets used for the 12 girders are given in Figures 6.1 through 6.4. Table I.5 gives the weight of each girder based on the average batch weight for its respective mix design.

Table I.1 Mix design weight pad1, pad2, and pad3

Batch No.	Cement (lbs)	Stone (lbs)	Sand (lbs)	Water (gal)	Water (lbs)	Admixtures (ozs)	Admixtures (lbs)	Weight (kips)
1	2811	6689	3569	85	709.0	233	15.2	13.79
2	2782	6668	3540	89	742.4	225	14.7	13.75
3	2816	6657	3517	90	750.8	231	15.1	13.76
4	2809	6664	3708	91	759.1	228	14.9	13.95
5	2801	6657	3629	91	759.1	229	14.9	13.86
6	2801	6640	3540	91	759.1	226	14.7	13.75
7	2799	6625	3491	91	759.1	229	14.9	13.69
8	2800	6619	3473	90	750.8	226	14.7	13.66
9	2801	6621	3495	90	750.8	230	15.0	13.68
10	2804	6632	3518	88	734.1	230	15.0	13.70
11	2790	6665	3676	88	734.1	226	14.7	13.88
12	2789	6649	3573	87	725.7	229	14.9	13.75
13	2804	6674	3488	79	659.0	231	15.1	13.64
14	2799	6689	3517	80	667.3	227	14.8	13.69
15	2801	6661	3522	82	684.0	226	14.7	13.68
16	2793	6655	3531	84	700.7	228	14.9	13.69
17	2801	6640	3569	86	717.4	230	15.0	13.74
18	2778	6628	3564	87	725.7	228	14.9	13.71
19	2814	6629	3540	87	725.7	230	15.0	13.72
20	2825	6626	3524	87	725.7	226	14.7	13.72
21	2803	6652	3525	88	734.1	228	14.9	13.73
22	2803	6665	3542	88	734.1	230	15.0	13.76
23	2802	6658	3529	82	684.0	226	14.7	13.69
							Avg. Wt. per yd^3 =	3.93

Table I.2 Mix design weight wax1, wax2, and none1

Batch No.	Cement (lbs)	Stone (lbs)	Sand (lbs)	Water (gal)	Water (lbs)	Admixtures (ozs)	Admixtures (lbs)	Weight (kips)
1	2801	6621	3545	99	825.8	228	14.9	13.81
2	2796	6620	3546	98	817.5	230	15.0	13.79
3	2810	6654	3550	101	842.5	228	14.9	13.87
4	2788	6638	3546	99	825.8	229	14.9	13.81
5	2805	6726	3541	98	817.5	228	14.9	13.90
6	2805	6687	3551	98	817.5	232	15.1	13.88
7	2799	6686	3542	98	817.5	228	14.9	13.86
8	2807	6683	3548	99	825.8	229	14.9	13.88
9	2797	6678	3545	98	817.5	228	14.9	13.85
10	2792	6670	3561	96	800.8	228	14.9	13.84
11	2809	6671	3592	98	817.5	228	14.9	13.90
12	2792	6658	3608	96	800.8	228	14.9	13.87
13	2786	6653	3535	99	825.8	228	14.9	13.81
14	2806	6639	3580	96	800.8	227	14.8	13.84
15	2796	6606	3565	98	817.5	227	14.8	13.80
16	2799	6607	3558	96	800.8	229	14.9	13.78
17	2790	6616	3559	97	809.1	227	14.8	13.79
18	2793	6632	3542	96	800.8	230	15.0	13.78
19	2795	6639	3534	96	800.8	228	14.9	13.78
20	2796	6670	3541	97	809.1	230	15.0	13.83
21	2801	6690	3552	98	817.5	228	14.9	13.88
22	2793	6690	3558	97	809.1	228	14.9	13.87
						Avg. Wt.	per yd^3 =	3.95

Table I.3 Mix design weight angle1, none2, and plate1

Batch No.	Cement (lbs)	Stone (lbs)	Sand (lbs)	Water (gal)	Water (lbs)	Admixtures (ozs)	Admixtures (lbs)	Weight (kips)
1	2641	6816	3629	88	734.1	217	14.1	13.83
2	2636	6836	3636	87	725.7	218	14.2	13.85
3	2628	6818	3633	89	742.4	217	14.1	13.84
4	2635	6835	3635	88	734.1	218	14.2	13.85
5	2624	6841	3594	89	742.4	216	14.1	13.82
6	2636	6845	3623	89	742.4	215	14.0	13.86
7	2633	6820	3601	88	734.1	215	14.0	13.80
8	2630	6817	3626	89	742.4	217	14.1	13.83
9	2627	6799	3615	87	725.7	215	14.0	13.78
10	2629	6805	3617	86	717.4	215	14.0	13.78
11	2625	6799	3620	87	725.7	215	14.0	13.78
12	2637	6825	3616	89	742.4	219	14.3	13.83
13	2628	6847	3642	88	734.1	217	14.1	13.87
14	2634	6845	3658	88	734.1	216	14.1	13.89
15	2631	6814	3657	89	742.4	215	14.0	13.86
16	2621	6829	3648	87	725.7	215	14.0	13.84
17	2636	6865	3645	86	717.4	216	14.1	13.88
18	2631	6863	3646	88	734.1	217	14.1	13.89
19	2708	6843	3650	86	717.4	215	14.0	13.93
20	2668	6839	3625	88	734.1	217	14.1	13.88
21	2655	6842	3632	87	725.7	217	14.1	13.87
22	2654	6809	3621	86	717.4	215	14.0	13.82
						Avg. Wt.	per yd^3 =	3.96

Table I.4 Mix design weight plate2, pad4, and angle2

Batch No.	Cement (lbs)	Stone (lbs)	Sand (lbs)	Water (gal)	Water (lbs)	Admixtures (ozs)	Admixtures (lbs)	Weight (kips)
1	2624	6857	3619	107	892.6	215	14.0	13.99
2	2629	6839	3587	110	917.6	215	14.0	13.97
3	2632	6841	3674	108	900.9	216	14.1	14.05
4	2632	6802	3752	108	900.9	215	14.0	14.09
5	2633	6811	3743	111	925.9	215	14.0	14.11
6	2643	6831	3690	108	900.9	221	14.4	14.06
7	2623	6833	3693	107	892.6	214	13.9	14.04
8	2631	6854	3674	110	917.6	219	14.3	14.08
9	2636	6835	3635	107	892.6	216	14.1	14.00
10	2645	6816	3658	108	900.9	215	14.0	14.02
11	2626	6841	3652	108	900.9	218	14.2	14.02
12	2635	6812	3692	110	917.6	216	14.1	14.06
13	2637	6788	3679	111	925.9	215	14.0	14.03
14	2630	6801	3701	109	909.2	217	14.1	14.04
15	2623	6807	3683	109	909.2	217	14.1	14.02
16	2618	6794	3665	107	892.6	217	14.1	13.97
17	2623	6804	3660	110	917.6	215	14.0	14.00
18	2623	6823	3654	111	925.9	217	14.1	14.03
19	2627	6857	3647	109	909.2	217	14.1	14.04
20	2644	6837	3687	110	917.6	215	14.0	14.09
21	2648	6795	3701	111	925.9	215	14.0	14.07
22	2637	6857	3592	109	909.2	216	14.1	14.00
						Avg. Wt.	per yd^3 =	4.01

Table I.5 Weight of girders

Ref. Name	Avg. Batch Weight From Mix (kip)	Volume (yd^3)	Girder Weight (kip)
None1	3.95	24.537	97.01
None2	3.96	24.459	96.75
Pad1	3.93	24.397	95.77
Pad2	3.93	24.399	95.78
Pad3	3.93	24.404	95.80
Pad4	4.01	24.460	98.09
Wax1	3.95	24.126	95.39
Wax2	3.95	24.537	97.01
Plate1	3.96	24.459	96.75
Plate2	4.01	24.460	98.09
Angle1	3.96	24.461	96.75
Angle2	4.01	24.460	98.09

REFERENCES

1. Hix, C.F. Jr. and R.P. Alley. *Physical Laws and Effects*, John Wiley & Sons, Inc. New York, NY, 1958. pp. 82-4.
2. *Building Code Requirements for Structural Concrete*, ACI 318-02, *and Commentary*, ACI 318R-02, American Concrete Institute, Detroit, MI, 2002.
3. *Standard Specifications for Highway Bridges*, 16th ed., American Association of State Highway and Transportation Officials, Washington, D.C., 1996.
4. Pytel, Andrew and Jaan Kiusalaas. *Mechanics of Materials*, Brooks/Cole – Thomson Learning. Pacific Grove, GA, 2003. pp. 29-30.
5. Persson, B. N. J. and E. Tosatti, ed. *Physics of Sliding Friction*, Kluwer Academic Publishers. Dordrecht, The Netherlands, 1996. pp. 69-89.
6. Nawy, E.G., *Prestressed Concrete A Fundamental Approach*, Third Edition, Prentice Hall, Upper Saddle River, New Jersey, 2000.
7. *PCI Design Handbook, Precast and Prestressed Concrete*, 6th Edition. Precast/Prestressed Concrete Institute, Chicago, IL, 2004.
8. Robinson, Thomas J. *Analytical Trigonometry*, Harper & Row Publishers, New York, NY, 1967.
9. Hernon, Peter. *Statistics: A Component of the Research Process*, Ablex Publishing Corporation, Norwood, New Jersey, 1991.